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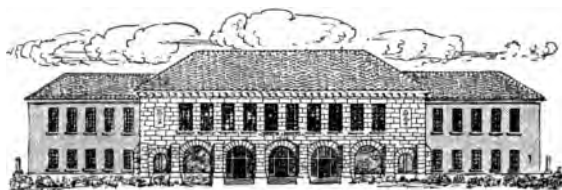
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IMPROVABILITY

Its Intercorrelations and Its Relations to Initial Ability

By

HENRIETTA V. RACE, Ph.D.

Teachers College, Columbia University
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HENRIETTA V. RACE

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CHAPTER I

THE INTERRELATIONS OF GAINS FROM PRACTICE IN DIFFERENT ABILITIES

THE RESULTS OF PREVIOUS INVESTIGATIONS

One of the most interesting and important problems of modern psychology is that of the nature of improvability. In a consideration of the subject, the degree of unity or specialization involved in the mental procedure is fundamental, so that a specific problem presents itself. How much unity and how much specialization is there in the learning process? A second problem, developing from the first, is the relation of improvability to initial ability, and a third, the relation of improvability to general ability.

We know that in the status reached at any age individuals differ in such ways as to make the intercorrelations between mental traits much below unity. Many of these intercorrelations are being determined by psychologists. Concerning the degree of unity or specialization in improvability, however, we know very little. The known facts are as follows: Wimms ('07, p. 68) found for improvability in addition with improvability in multiplication a correlation of $-.007$. Chapman ('14, p. 31-35 *passim*), who gave especial attention to the matter, says: "Of all the problems of individual differences which yet await solution, none is of greater interest than that concerned with the general improvability of individuals in various functions. If it is true that an individual who over a certain specified time gains a certain amount in one test is likely to gain a certain corresponding amount in other tests and if with many subjects this correlation is high, we shall be able to arrange individuals in order of merit with regard to general improvability, in this way obtaining a criterion for the selection of those persons who are likely to benefit most by education."

He reports the following raw correlations:

TABLE I
CORRELATION BETWEEN IMPROVABILITIES
—Chapman ('14, p. 31-35)
Individuals 1-22. Measure of Improvement
1. Score $(6+7+8) - \text{Score } (1+2+3)$
2. Score $(9+10) - \text{Score } (4+5)$

	Color $(6+7+8) - (1+2+3)$	Color $(9+10) - (4+5)$	Cancellation 2 $(6+7+8) - (1+2+3)$	Cancellation 2 $(9+10) - (4+5)$	Cancellation 3 $(6+7+8) - (1+2+3)$	Cancellation 3 $(9+10) - (4+5)$	Opposites $(6+7+8) - (1+2+3)$	Opposites $(9+10) - (4+5)$	Addition $(6+7+8) - (1+2+3)$	Addition $(9+10) - (4+5)$	Mental multiplication $(6+7+8) - (1+2+3)$	Mental Multiplication $(9+10) - (4+5)$
Color:												
$(6+7+8) - (1+2+3)$		.19	-.22	-.03	-.26	-.19	.56	.63	-.17	-.13	-.41	.02
$(9+10) - (4+5)$			-.32	.37	.05	-.06	.05	.14	-.14	.02	.02	.37
Cancellation 2:.....												
$(6+7+8) - (1+2+3)$				.35	.66	.20	.14	-.05	.28	.20	.17	-.08
$(9+10) - (4+5)$.....					.50	.55	.02	.08	.13	.14	.25	.22
Cancellation 3:												
$(6+7+8) - (1+2+3)$						.31	.08	-.11	.40	.44	.22	.13
$(9+10) - (4+5)$.....							.17	.17	.14	.03	.60	-.02
Opposites:												
$(6+7+8) - (1+2+3)$								.65	.26	.31	-.25	-.11
$(9+10) - (4+5)$									-.06	-.17	-.16	-.16
Addition:												
$(6+7+8) - (1+2+3)$										.40	.08	-.02
$(9+10) - (4+5)$											-.09	-.17
Ment. multiplication:												.48
$(6+7+8) - (1+2+3)$												
$(9+10) - (4+5)$												

Of these facts he says:

The interpretation of these tables is somewhat difficult. In order to gain an idea of the correction for attenuation, two measurements of improvement are calculated.

1. Scores $(6 + 7 + 8)$ tests — scores $(1 + 2 + 3)$ tests
2. Scores $(9 + 10)$ tests — scores $(4 + 5)$ tests

These two scores of the improvement can be regarded as the early and late improvement respectively.

Not to apply any correction for attenuation in the cases where it is possible is certainly to minimize the value of the results. The correction for attenuation, however, becomes unsuitable when the correlations are very low or of negative value. Perhaps the best method is to make no use of the attenuation

correction but to consider the values of the correlations between the gains in the cancellation 2 and the cancellation 3 tests. The almost complete identity of elements which exists between these two operations justifies the assumption that apart from chance errors in the data, the coefficient should be almost unity. The actual value of this raw coefficient, if we take the average of the four determinations, is .48. This indicates that apart from errors which must enter, especially in the measurement of improvement, a correlation of approximately .5 represents a true correlation of approximately unity. If each one of these coefficients when of sufficiently high value above zero is interpreted with this in mind, something approaching a true estimate of correct values may be obtained. . . . In no instance does this value rise sufficiently high to justify any definite statements of numerical values. While recognizing that these values are subject to a large attenuation correction, there is no doubt that under the conditions of these experiments there is no such function as high general improvability. All that we can say is that after correction for attenuation is made, there would probably be a small positive correlation between improvements made in the various tests.

GENERAL PLAN OF THE EXPERIMENTS OF THE PRESENT INVESTIGATION

Personnel. The personnel of the experiments of this investigation included ninety-five college students in the department of education of Southwestern College, forty-three children of superior intelligence and one hundred and seventy-two children of average ability.

The college students were of junior and senior standing. They were divided into three groups for distribution of time so that we have with them experiments A, B, and C.

The children of superior intelligence were in two classes designated in this study as Class S I¹ and Class S II. Their eligibility for the classes and experiments was determined by the Binet-Simon tests. The lower limit of the entrance requirement was an intelligence quotient of 124. Class S I began the experiments in February, 1918. It consisted of twenty-three children with an average chronological age at that date of 9.2 years and an average intelligence quotient of 144. Class S II took up the work in February, 1919. It was composed of twenty children with an average

¹ Class S I was partially organized in October, 1916, at the Mary D. Hill School. Part of this class with others added to form a new class was reorganized at the Normal School February, 1917.

age at that time of 9.8 years, and an average intelligence quotient of 136.7. All the children of superior intelligence were selected from the 3A, 4A and 4B grades of the city at large. There have been a few changes in the membership of these classes since their organization, six children having left and six having entered. As a whole the classes have remained intact.

The control groups with which the comparisons are made were classes of the regular school grades 4B, 4A, 5B, 7B¹ and 7B². The average chronological age of the fourth and fifth grade groups at the beginning of this practice was 10.9 years, that of the seventh grade groups 13.5 years. All of these children, at the time these experiments were conducted, were in the public schools of the city of Louisville.

Material. The materials for practice, all of which are shown later in detail, were (a) addition of one column numbers, (b) multiplication by substitution, (c) cancellation, (d) language completion, (e) reasoning processes in United States history, and (f) fifteen forms of Part I of the Thorndike Intelligence Examination for High School Graduates.

Treatment. Gains were measured for each individual as the actual changes from some defined early status to some defined later status. Each individual's gain in each ability is then expressed as a + or - deviation from some defined central tendency of gain in his group. The "raw" correlations between the gains so expressed are found by the Pearson formula

$$r = \frac{\Sigma x \cdot y}{\sqrt{\Sigma x^2} \sqrt{\Sigma y^2}}$$

In all measures of groups of individuals the coefficient of correlation is attenuated by chance errors in the original data. The two measures of each function were taken each time the tests were given in order to provide for correction. To correct for attenuation the formula

$$r_{pq} = \frac{\sqrt[4]{(r_{p1q1})(r_{p1q2})(r_{p2q1})(r_{p2q2})}}{\sqrt{(r_{p1p1})(r_{q1q1})}}$$

or some equivalent procedure is used.

EXPERIMENTS WITH COLLEGE STUDENTS

The experiments with college students consisted of practice in addition, multiplication by substitution, and cancellation.¹ The addition material was that used by Thorndike, Kirby, Chapman, and Garth. It consists of sheets of forty-eight one-figure addition problems of ten numbers each, ones and zeros omitted. Seven different sheet arrangements were designed to prevent memory of answers.

The multiplication by substitution material, devised by Thorndike, is an arrangement of pairs of numbers or couplets from 11 to 19. There are eighty couplets on a sheet and six different sheet formations. The numbers which make up the couplets are associated together by the substitution of answers found on a key sheet. The key sheet is a multiplication table, the answers being arranged in columns with the factors 11, 12, 13, 14, to 19 on the horizontal and perpendicular margins of the sheet. The product of each couplet on the practice sheet is found at the cross-section of the columns of the key.

The cancellation material is that of Woodworth and Wells. It consists of a series of eight different sheets of random groupings of five figures. The work of the practice was to cancel out each group that contained some designated figure or figures.

Experiment A. Thirty-one students participated in this experiment. The length of time of the practice was thirty consecutive days, barring Sundays. Each of the three functions was practiced on 8 days for 20 minutes a day, or 160 minutes. On the first, tenth, twentieth, and thirtieth days, all of the tests of the experiment were given. The addition tests consisted of the addition of problems on sheets 1 and 2 of the series. Four minutes were allowed for each. In multiplication by substitution a four-minute test was given with each of sheets (M1) and (M2). The students were to find right answers for the couplets on the test sheets, the key in hand.

The work of the cancellation test was to cancel out each number containing both 2 and 3 on one sheet, 8 and 9 on a second sheet, 4 on a third, and 7 on a fourth sheet. The time was 60 seconds for each sheet. Each of these four tests was repeated.

¹Samples of materials are found in the Appendix.

On the first day of the experiment, the tests in addition, multiplication by substitution, and cancellation were given. On the second day, the practice in addition began and continued until the tenth day. At the close of the practice on the tenth day of the experiment all of the tests in addition, multiplication by substitution, and cancellation were again given. On the eleventh day of the experiment, practice on the multiplication by substitution was taken up. The students practiced for 8 days, 20 minutes a day on this material, using four different sheet arrangements. At the close of the eighth practice, on the twentieth day of the experiment, all the tests were given again.

On the twenty-first day and for eight days thereafter, 20 minutes a day, the students practiced on cancellation. Groups containing the following pairs of numbers were cancelled on the series of sheets in the order: 2 and 3, 4 and 5, 6 and 7, 8 and 9, 2 and 4, 3 and 6, 5 and 7, 6 and 8, 7 and 9, 8 and 2, 9 and 3. The time, as in the former practice periods, was 20 minutes a day for 8 days. At the end of the time the tests in all three subjects were given again.

Experiment B. Twenty-eight students worked through this experiment. The materials for practice and the plan of procedure in tests and practice were the same as in Experiment A, excepting the time distribution. In Experiment B, the practice requirements were two 20-minute periods a week. The practice continued through fifteen weeks until the same time was spent in Experiment B as in Experiment A, the difference being in the extended intervals between practice. Like procedure as to tests established them in the first, tenth, twentieth, and thirtieth periods.

Experiment C. Thirty-two students were engaged in the tests and practices of Experiment C. The only change in the procedure was again in the time intervals. The entire work of Experiment C was done in three and one-half days. The practice periods were 20 minutes every hour of the working day as follows: First hour practice, 11:00 o'clock to 11:20; second, 12:00 to 12:20; third, 1:00 to 1:20; fourth, 2:00 to 2:20; fifth, 3:00 to 3:20; sixth, 4:00 to 4:20; seventh, 5:00 to 5:20; eighth, 6:00 to 6:20, for the first day with repetitions for the second and third days until all practices were taken. The tests were given at 9:30 on the first day,

at 10:30 on the second, and at 9:30 on the third and fourth days, as they would regularly come in at periods one, ten, twenty, and thirty.

To illustrate the test procedure, the scores of Miss H. on the first, tenth, twentieth, and thirtieth days of the practice are given. She received test credits as follows, "r" representing "repeat":

TEST	DAY	ADDITION r		SUBSTITUTION r		CANCELLATION							
						(2&3)	(8&9)	(4)	(7)	(2&3)	(8&9)	(4)	(7)
						r	r	r	r	r	r	r	r
I	1st	15	15	31	49	22	25	54	56	30	28	60	61
II	10th	25	28	57	64	26	28	64	61	29	30	65	66
III	20th	26	26	134	132	35	25	66	67	35	29	70	76
IV	30th	23	23	107	128	40	42	74	83	43	43	83	90

In addition and multiplication by substitution, credit of one point was given for every correct response. In cancellation, the score was the number of groups rightly marked — 1 for each group omitted that should have been marked and — 2 for each group wrongly marked.

The selection for the measurement of the improvement was made on the basis of greatest improvement for the group. In addition, the greatest improvement was made between Test I repeat of the first period and Test II repeat of the tenth period; in multiplication by substitution, between Test I repeat of the first period and Test IV repeat of the thirtieth period; in cancellation, between Test I repeat of the first period and Test IV repeat of the thirtieth period.

Tables 2, 3, and 4 give these scores for each individual. By subtracting the 'early' from the 'late' scores, measures of gain are derived. In the case of addition and cancellation the data of Tables 2, 3, and 4 also provide material to correct for attenuation, that is, to estimate what various intercorrelations would be if the chance variations of individuals from their true abilities were excluded. In the case of the multiplication or substitution work, data permitting of this correction were available in the records of Tests I, II, and IV.

The resulting correlations are shown raw in Table 5 and corrected for attenuation in Table 6.

TABLE 3
ORIGINAL DATA: COLLEGE STUDENTS
EXPERIMENT B

Number	ADDITION						SUBSTITUTION						CANCELLATION												
	Test I			Test II			Test Ir	Test I						Test IVr											
	1	2	S	1	2	S	G	1	2	G	2&3	8&9	S	4	7	S	2&3	8&9	S	G	4	7	S	G	
1	8	4	12	9	10	19	7	26	72	46	18	15	33	40	42	82	33	24	57	24	73	60	133	51	
2	26	23	49	40	39	79	30	34	82	48	22	23	45	57	58	115	35	32	67	22	67	75	142	27	
3	13	14	27	21	20	41	14	37	103	66	24	22	46	49	59	108	36	32	68	22	82	85	167	59	
4	4	4	4	20	21	24	45	62	122	60	13	26	35	44	47	79	33	29	62	36	71	82	153	74	
5	15	15	30	27	25	52	22	44	107	63	23	21	44	47	58	105	38	36	74	30	69	82	151	46	
6	6	6	6	17	19	22	41	17	44	73	29	17	18	35	54	51	105	32	25	57	22	70	67	137	32
7	11	12	23	17	19	36	13	17	44	27	17	17	34	38	43	81	24	26	50	16	49	57	106	25	
8	10	13	23	16	19	35	12	56	132	76	25	25	50	64	58	122	37	35	72	22	73	78	151	29	
9	9	9	21	19	17	36	15	45	85	40	21	21	42	52	62	114	36	33	69	27	71	69	140	26	
10	15	11	26	25	22	47	21	48	84	36	18	13	31	46	46	92	29	25	54	23	65	61	126	34	
11	7	2	9	18	18	36	27	62	136	74	23	18	41	51	61	112	36	34	70	29	89	91	180	68	
12	18	17	35	24	25	49	14	49	103	54	19	16	35	49	59	108	30	27	57	22	66	67	133	25	
13	7	7	14	21	23	44	30	46	119	73	22	22	44	46	56	102	48	40	88	44	79	108	187	85	
14	18	18	36	26	25	51	15	40	62	22	23	18	41	50	53	103	35	29	64	23	68	77	145	42	
15	8	12	20	23	24	47	27	60	95	35	23	21	44	56	54	110	45	38	83	39	79	77	156	46	
16	23	20	43	35	31	66	23	57	114	57	18	22	40	43	57	100	37	35	72	32	76	87	163	63	
17	10	8	18	19	17	36	18	52	125	73	23	27	52	55	54	109	33	45	78	26	77	82	159	50	
18	10	6	16	13	8	21	5	35	74	39	15	15	30	44	53	97	38	27	65	35	60	68	128	31	
19	15	22	37	24	26	50	13	45	105	60	22	18	40	59	50	109	33	24	57	17	75	79	154	45	
20	17	15	32	23	20	43	11	44	86	42	24	22	46	44	53	97	32	27	59	13	60	73	133	36	
21	13	12	25	17	15	32	7	42	78	36	25	21	46	59	52	111	31	31	62	16	71	68	139	28	
22	12	14	26	23	23	46	20	38	72	34	16	13	29	44	42	86	30	28	58	29	70	60	130	44	
23	12	13	25	31	32	63	38	69	147	78	37	34	71	72	80	152	66	55	121	50	110	16	226	74	
24	11	9	20	19	23	42	22	53	84	31	23	18	41	42	49	91	51	41	92	51	82	100	182	91	
25	10	9	19	10	13	23	4	49	75	26	19	13	42	69	59	128	34	34	68	26	73	72	145	17	
26	15	13	28	23	27	50	22	42	96	56	16	18	34	65	52	117	37	26	63	29	77	76	153	36	
27	10	9	19	19	16	35	16	36	74	38	17	20	37	49	54	103	28	25	53	16	68	70	138	35	
28	5	3	8	16	15	31	23	15	82	67	19	22	41	63	54	117	38	35	73	32	83	74	157	40	

TABLE 5
RAW CORRELATIONS BETWEEN GAINS

EXPERIMENT A		
	<i>r</i>	P. E.
Addition and Multiplication by Substitution.....	.50	.09
Addition with Cancellation (2&3) (8&9).....	.35	.105
Addition with Cancellation (4) (7).....	.22	.11
Multiplication with Cancellation (2&3) (8&9).....	.29	.11
Multiplication with Cancellation (4) (7).....	.07	.12
Cancellation (2&3) (8&9) with Cancellation (4) (7).....	.58	.04
EXPERIMENT B		
Addition with Multiplication by Substitution.....	.44	.10
Addition with Cancellation (2&3) (8&9).....	.60	.08
Addition with Cancellation (4) (7).....	.56	.08
Multiplication with Cancellation (2&3) (8&9).....	.26	.12
Multiplication with Cancellation (4) (7).....	.44	.10
Cancellation (2&3) (8&9) with Cancellation (4) (7).....	.72	.09
EXPERIMENT C		
Addition with Multiplication by Substitution.....	.09	.12
Addition with Cancellation (2&3) (8&9).....	.05	.12
Addition with Cancellation (4) (7).....	.26	.11
Multiplication with Cancellation (2&3) (8&9).....	.19	.11
Multiplication with Cancellation (4) (7).....	.24	.11
Cancellation (2&3) (8&9) with Cancellation (4) (7).....	.47	.09

TABLE 6
CORRELATIONS BETWEEN GAINS CORRECTED FOR ATTENUATION

EXPERIMENT A	
	<i>r</i>
Addition with Multiplication by Substitution.....	.84
Addition with Cancellation (2&3) (8&9).....	.86
Addition with Cancellation (4) (7).....	.45
Multiplication with Cancellation (2&3) (8&9).....	.46
Multiplication with Cancellation (4) (7).....	.10
Cancellation (2&3) (8&9) with Cancellation (4) (7).....	1.14
EXPERIMENT B	
Addition with Multiplication by Substitution.....	.76
Addition with Cancellation (2&3) (8&9).....	.97
Addition with Cancellation (4) (7).....	.90

	<i>r</i>
Multiplication with Cancellation (2&3) (8&9).....	.37
Multiplication with Cancellation (4) (7).....	.62
Cancellation (2&3) (8&9) with Cancellation (4) (7).....	.96

EXPERIMENT C

Addition with Multiplication by Substitution.....	.16
Addition with Cancellation (2&3) (8&9).....	.11
Addition with Cancellation (4) (7).....	.70
Multiplication with Cancellation (2&3) (8&9).....	.29
Multiplication with Cancellation (4) (7).....	.40
Cancellation (2&3) (8&9) with Cancellation (4) (7).....	1.06

AVERAGE OF RESULTS IN EXPERIMENTS A, B, AND C

	<i>r</i>	P. E.
Addition with Multiplication by Substitution.....	.59	.12
Addition with Cancellation (2&3) (8&9).....	.65	.15
Addition with Cancellation (4) (7).....	.68	.07
Multiplication (Substitution) with Cancellation (2&3) (8&9).....	.37	.03
Multiplication (Substitution) with Cancellation (4) (7).....	.37	.08
Cancellation (2&3) (8&9) with Cancellation (4) (7).....	1.05	.03

Table 6, if taken at its face value, shows that in the case of these adult students, improvability is specialized, the corrected correlations being considerably below 1.00. This is true except for the two slightly different forms of cancellation, where it is 1.00, as would be expected. An individual's ability to improve is not the same for all forms of mental operation with all forms of content, but varies notably. Between the learning to give the products of numbers from the continued use of the key and the learning to find and cancel numbers, the difference in improvability is very great.

**EXPERIMENTS WITH CLASSES OF CHILDREN OF SUPERIOR
INTELLIGENCE**

The personnel of this experiment included forty children of superior intelligence grouped in the two classes, S I and S II.

The tests and practice procedure in this part of the investigation were selected in part with a view to securing data on improvement in selective thinking in comparison with associative activities.

The materials for practice, which are shown in the Appendix, were (a) addition of one-figure numbers, (b) multiplication by

substitution, (c) language completion, (d) reasoning processes in United States history, and (e) Section I, Part I, of the Thorndike Intelligence Examination for High School Graduates.

Addition. Thirty-eight children of Class S I and Class S II made up the personnel of this group. The material for practice and test was the same as that described in the preceding section. The addition practice was eight minutes a day for ten days, making a total of eighty minutes. The days of practice were continuous except for week-end vacations. Two tests of four minutes each were given at the beginning and at the close of the practice period. Credit of one point was given for every problem correctly added. In illustration of the test and practice procedure, taking R.G.'s record from the work of Class S II as an example, he added problems correctly in the initial and final tests and in the practice as follows:

TEST					PRACTICE					TEST		
I&II	Mon.	Tues.	Wed.	Thur.	Fri.	Mon.	Tues.	Wed.	Thur.	Fri.	I&II	
25	25	31	31	29	33	31	36	37	38	36	38	

R. G. then made a gain from the sum of the first two tests before the practice began to the sum of the last two after the close of the practice of 38-25, or thirteen problems.

Multiplication by Substitution. Forty children from Classes S I and S II participated in these tests. The material used was the same as that used by the college students and described in the previous section. The distribution of practice was one period a day for 20 days, making a total of 160 minutes. Two tests of four minutes each were given at the beginning and at the close of the practice period. The score was one point credit for every answer right.

To illustrate the test and practice procedure: S. M. of Class S I practiced 8 minutes a day for 20 days with initial and final test scores as follows:

TESTS										PRACTICE										TESTS									
I&II	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	I&II								
30	62	74	77	77	80	84	89	90	81	89	96	95	94	102	110	103	108	111	112	112	111								

S. M. then made a gain from the sum of the first two tests before the practice began, to the sum of the last two tests after the practice closed, of 111-30, or 81 couplets right.

Language Completion. Forty children of Class S I and Class S II made up this group. The language-completion tests were Trabue Language Scales, B, C, D, and E. These tests were made up of sentences from which certain words had been omitted, arranged in a scale of difficulty. The test is to fill in the blank spaces with words which will fit the sentences. Scales B and C were given at the beginning of the practice, and Scales D and E at the close. The material of the practice for each child was a 160-page edition of *Aesop's Fables* with ten words on a page blanked out. No attempt was made to scale the practice material for definite values in the blanking of words, the selection of words to be discarded, being made on the basis of meaning values only.

The distribution of time for practice was 10 minutes a day for twenty days. It consisted of writing in the margins of the pages of the book the missing word or any word which would complete the meaning of the dismembered sentences. In the practice, credit of one point was given for every correct completion. Credit was given in the tests according to the Trabue requirement of two for every sentence correct.

To illustrate: G. C. of Class S II filled in words to complete sentences, working 10 minutes a day for 20 days, as follows:

TEST		PRACTICE																				TESTS	
B	AND C	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	D & E	
17	12	39	23	49	60	50	60	64	73	65	72	90	62	88	56	66	77	63	67	87	85	14 18	

G. C. made a gain from the sum of the standings of the first two tests to the sum of the standings of the last two, by virtue of the twenty days' practice, of 32-29, or a gain of 3 over his first standing.

Reasoning Processes in United States History. The personnel of this experiment included two classes of children of superior intelligence, numbering together forty-two children.

The material for practice was one hundred questions in United States history running through the Colonial period. A sample shows the nature of the questions:

Before the Pilgrims landed they met in the cabin of the Mayflower and made a compact, stating that they had undertaken the voyage for the glory of God, the advancement of the Christian faith, and in honor of their king and country. They declared, "We do solemnly and mutually, in the presence of

God and one another, covenant and combine ourselves together into a civil body politic for our better ordering and preservation, and the furtherance of the end aforesaid and by virtue hereof to enact, constitute, and frame such just and equal laws as shall be thought most meet and convenient for the general good."

- a. Which statement shows loyalty to England?
- b. Which two statements show a belief in democracy?

The children had never studied United States history in the Colonial period before, so they were obliged to make their own conclusions.

The practice consisted of five questions a day. One recitation period of forty minutes each day for twenty days was devoted to the work. At the beginning of the period the children were given the five questions for the day's consideration on printed sheets with space for answers. They were allowed fifteen minutes to answer the questions in writing. Then the papers were taken up and class discussion occupied the remainder of the recitation time. At the beginning of the next recitation period the children were told the number of questions answered correctly the day before. No attempt was made to scale the questions for difficulty. In the scoring, each question was arbitrarily given a value of 3. The limit of the day's attainment was a score of 15. The tests were the Van Wagenen American History Scales, Thought Scales A and B. These tests were made up of twenty-nine questions involving reasoning processes, each with a value of 3. Scale A was given at the beginning of the practice, Scale B on the tenth day, and both scales at the close of the practice.

To illustrate: W. R. of Class S I practiced and took tests, receiving credit as follows:

TESTS										PRACTICE										TESTS									
A & B	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	A & B								
50	10.5	6.5	12.5	15.0	14.0	7.5	13.5	10.5	12.0	14.0	7.5	12.0	7.5	9	10.5	12	12	15	15	12	70								

W. R. made a gain of 20 points from 50, the result of the initial test, to 70, the result of the final test, by virtue of the twenty days' practice in reasoning processes.

Thorndike Intelligence Examination for High School Graduates. This problem was taken up in April, 1920, by Class S I and a control group of children of average intelligence. Class S I consisted, at

TABLE 8
ORIGINAL DATA: CHILDREN OF AVERAGE INTELLIGENCE

No.	ADDITION						SUBSTITUTION						HISTORY 5A		HISTORY 7B	
	BEGINNING			END			BEGINNING			END			BEG.	END	BEG.	END
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	1	2
1	13	17	30	27	49	19	13	13	2	6	7	15	2	30	5	54
2	13	14	27	21	19	40	13	13	7	15	17	32	12	15	21	54
3	9	5	14	10	21	21	7	12	0	15	22	44	6	6	0	21
4	10	20	14	22	34	8	9	6	15	0	23	22	45	6	0	45
5	8	5	13	12	22	11	6	15	0	23	22	45	6	6	0	45
6	5	10	18	10	18	8	6	14	1	24	35	59	53	34	34	34
7	10	8	18	10	18	8	6	14	1	24	35	59	53	34	34	34
8	10	8	18	10	18	8	6	14	1	24	35	59	53	34	34	34
9	5	3	8	7	14	6	4	11	15	27	18	14	39	70	35	70
10	5	3	8	7	14	6	4	11	15	27	18	14	39	70	35	70
11	5	3	8	7	14	6	4	11	15	27	18	14	39	70	35	70
12	5	3	8	7	14	6	4	11	15	27	18	14	39	70	35	70
13	10	9	10	11	20	10	4	11	15	27	18	14	39	70	35	70
14	10	9	10	11	20	10	4	11	15	27	18	14	39	70	35	70
15	8	5	13	7	14	6	4	11	15	27	18	14	39	70	35	70
16	11	6	17	14	19	33	2	1	11	22	30	25	55	41	11	58
17	6	12	20	17	19	33	2	1	11	22	30	25	55	41	11	58
18	8	8	14	10	11	21	7	3	1	22	30	25	55	41	11	58
19	8	8	14	10	11	21	7	3	1	22	30	25	55	41	11	58
20	18	20	38	24	48	10	4	8	10	4	33	38	71	48	38	60
21	1	0	11	1	7	6	4	10	5	9	19	27	43	24	15	35
22	1	0	11	1	7	6	4	10	5	9	19	27	43	24	15	35
23	1	0	11	1	7	6	4	10	5	9	19	27	43	24	15	35
24	1	0	11	1	7	6	4	10	5	9	19	27	43	24	15	35
25	1	0	11	1	7	6	4	10	5	9	19	27	43	24	15	35
26	1	0	11	1	7	6	4	10	5	9	19	27	43	24	15	35
27	1	0	11	1	7	6	4	10	5	9	19	27	43	24	15	35
28	1	0	11	1	7	6	4	10	5	9	19	27	43	24	15	35
29	1	0	11	1	7	6	4	10	5	9	19	27	43	24	15	35
30	1	0	11	1	7	6	4	10	5	9	19	27	43	24	15	35
31	1	0	11	1	7	6	4	10	5	9	19	27	43	24	15	35
32	1	0	11	1	7	6	4	10	5	9	19	27	43	24	15	35
33	1	0	11	1	7	6	4	10	5	9	19	27	43	24	15	35
34	1	0	11	1	7	6	4	10	5	9	19	27	43	24	15	35
35	1	0	11	1	7	6	4	10	5	9	19	27	43	24	15	35
36	1	0	11	1	7	6	4	10	5	9	19	27	43	24	15	35
37	1	0	11	1	7	6	4	10	5	9	19	27	43	24	15	35
38	1	0	11	1	7	6	4	10	5	9	19	27	43	24	15	35
39	1	0	11	1	7	6	4	10	5	9	19	27	43	24	15	35
40	1	0	11	1	7	6	4	10	5	9	19	27	43	24	15	35
41	1	0	11	1	7	6	4	10	5	9	19	27	43	24	15	35
42	1	0	11	1	7	6	4	10	5	9	19	27	43	24	15	35
43	1	0	11	1	7	6	4	10	5	9	19	27	43	24	15	35
44	1	0	11	1	7	6	4	10	5	9	19	27	43	24	15	35
45	1	0	11	1	7	6	4	10	5	9	19	27	43	24	15	35
46	1	0	11	1	7	6	4	10	5	9	19	27	43	24	15	35
47	1	0	11	1	7	6	4	10	5	9	19	27	43	24	15	35
48	1	0	11	1	7	6	4	10	5	9	19	27	43	24	15	35
49	1	0	11	1	7	6	4	10	5	9	19	27	43	24	15	35
50	1	0	11	1	7	6	4	10	5	9	19	27	43	24	15	35

the time, of twenty-one children, of whom nineteen are recorded in the results. The material for the practice was devised by Dr. Thorndike as part of an intelligence examination for high school graduates. Section I, Part I, of the complete examination was used. It consists of thirteen different practice elements, (1) following directions tests; (2) mixed true or false sentences; (3) association problems in arithmetic; (4) reasoning problems in arithmetic; (5) information tests; (6) opposites; (7) common-sense tests; (8) number association; (9) analogies; (10) discrimination of numbers; (11) discrimination of facts; (12) logical exercises; (13) memory of figures and forms. Forms A, B, C, D, etc., were used in order.

The practice continued for 15 days, 30 minutes a day. There were no end tests. The credit was the official score. In illustration, N. G. of Class S I received the following credits for each of the 15 days' practice:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
107	127	137	119	117	134	133	141	130	139	128	127	124	130	131

N. G. then gained from the total initial practice of 107 points to the final practice of 131 points, making a gain of 24 points by reason of the fifteen days' practice. Pages 16 and 17 give original data for children of superior intelligence and children of average ability.

Tables 7 and 8 give the initial and final test-scores for each individual in each ability. From these, gains are computed, turned into deviations from the average of the group, and correlated.

The raw correlations are as shown in Table 9.

TABLE 9
RAW CORRELATIONS OF GAINS: CHILDREN OF SUPERIOR INTELLIGENCE

Addition and Substitution .....	.61
Addition and Language .....	.01
Substitution and Language .....	.04
Addition and History .....	.075
Substitution and History	— .25
Language and History .....	.25
Thorndike Test and Addition .....	.012
Thorndike Test and Substitution	— .16
Thorndike Test and Language .....	.05
Thorndike Test and History .....	.17

Before inferring anything from these correlations, however, the following corrections are made:

Addition. Find r_{ag1ag2} by correlating the gains used above with the gains, using Test 1 of the initial with Test 1 of the final score, and Test 2 of the initial with Test 2 of the final score. The r_{ag1ag2} will be used in the denominator wherever addition gains are involved in the raw correlation to be corrected.

Multiplication by Substitution. Find r_{sg1sg2} by correlating the gains used above with the gains using the first and last test scores, as in the case of addition. The r_{sg1sg2} will be used in the denominator wherever substitution gains are involved in the raw correlation.

Language Completion. Find the gains from Test B to Test E and from Test C to Test D. These are correlated and the formula developed by Spearman (sometimes referred to as Brown's Formula) is applied to determine the r_{lg1lg2} that would probably have been found between (a) the gain from B+C to D+E and (b) the gain from B¹+C¹ to D¹+E¹ if alternative tests for B, C, D, and E had been available.* The r_{lg1lg2} is then used in the same fashion as r_{ag1ag2} and r_{sg1sg2} .

Reasoning Processes in United States History. After splitting the initial and final tests into two random halves, we proceed as in the case of Language Completion, to obtain r_{hg1hg2} .

Thorndike Intelligence Examination Score. r_{lg1lg2} is determined by finding the gains from the second to the fourteenth practice, and correlating them with the gains from the first to the fifteenth. r_{lg1lg2} is used in the same way as the other self-correlations.

The results of these computations are:

		P.E.
r_{ag1ag2}	= .627	.05
r_{12}	= .93	.08
r_{lg1lg2}	= -.12	.11
r_{hg1hg2}	= .83	.08
r_{lg1lg2}	= .52	.11

It is clear from these self-correlations that any intercorrelations

$$*r_{lg1lg2} = \frac{2r_{lg1lg2}}{1+r_{lg1lg2}} \text{ where } r_{lg1lg2} = r(E-B)(D-C)$$

involving the language completion gains are uninterpretable. Raw correlations involving them are determined chiefly by chance deviations; and correction for attenuation is fruitless.

The corrected correlations excluding Language Completion are:

Addition with Substitution .....	.69
Addition with History .....	.104
Substitution with History	— .28
Substitution with Thorndike Test	— .32
Thorndike Test with Addition .....	.02
Thorndike Test with History .....	.26

DISCUSSION OF RESULTS AND CONCLUSIONS

A study of the correlations of gains given in the preceding pages reveals a certain amount of relationship between the different gains in both the college students and the children of superior intelligence. That all the correlations are low, except in the cases of very similar abilities such as the two forms of cancellation, may be due in part to two factors which appear in all. First, both the college students and the children of superior intelligence form highly selective homogeneous groups. It is a common experience among statisticians to find that such groups afford lower coefficients of correlation than more diversified groups. Second, and most important, the initial ability of many individuals of both groups places them high on the scale where improvement becomes more difficult because of approach to the limit of efficiency of the function measured. An approach to the parabolic form in the curve of practice in these functions is frequently found. Since every step in the upper portion of such a curve is accomplished with increasing difficulty, an individual who scores high in initial tests has less chance of gross improvement. This may influence the correlations markedly. It tends to raise them unduly in so far as an individual is at the start at a relatively early stage in the practice curve in both abilities and to lower them unduly in proportion as he is at an early stage in one and at a late stage in another. In language, the scale, even though extended by the use of two sections B and C in the first test and D and E in the second, approaches its limit very rapidly. In the development of the scale as in all similar ones, the first element is made so simple that almost anyone can complete it,

the last so difficult that comparatively few can do so. In other words, the first element of the scale represents the first step above zero ability, the last the highest extent of the measurement. The number of sentences of the language scale being few, ten in fact, and the grade value being fixed as equal for the extent of the scale, improvement in the upper levels is measured in constantly decreasing returns, and hence the limit of ability is reached precipitately. The fact is illustrated by the Trabue standards for grades.

	STANDARD	IMPROVEMENT
Grade 3.....	6.0	3.0
Grade 4.....	8.0	2.0
Grade 5.....	9.6	1.6
Grade 6.....	11.0	1.4
Grade 7.....	12.3	1.3
Grade 8.....	13.3	1.0

As the higher grades are reached, the improvement decreases as shown.

The history scales are more extended than the language scales, but the same characteristic prevails to some extent.

In general, the correlations between gains fall far short of 1.00, and seem to be little if any higher than the corresponding correlations between measures of status would probably be. Improva-
bility or learning seems to be specialized rather than unitary.

CHAPTER II

THE RELATION OF IMPROVABILITY TO INITIAL ABILITY IN THE FUNCTION ITSELF

Initial ability is considered here to mean ability due to original nature plus experience in the function up to the time when the practice in the experiment began. The question may be stated: To what extent will the individual who stands high in the initial tests improve as compared with the one who stands low in the initial tests?

This problem involves the very difficult matter of equating units at different levels. For example, in comparing the gain from 30 to 40 additions per minute with that from 40 to 50, we should all probably agree that the latter represented a greater gain than the former, but there would be wide variation in estimates of just how much greater. In what follows we shall uniformly report the gross gains and the initial abilities on which there are gains, leaving the reader to exercise his own judgment in attaching more weight to the units of gross gains in the upper ranges of the practice curve.

RESULTS OF PREVIOUS INVESTIGATIONS

Data are available in the work of Wimms ('07), Thorndike ('08 and '10), Starch ('11), Whitley ('11), Wells ('12), Thorndike and Donovan ('13), Kirby ('13), Thorndike and Hahn ('14), Chapman ('14), Brown ('14), Thorndike ('15), Thorndike ('16), Peterson ('17), Myers ('18), and Chapman ('19).

Wimms ('07) worked out an experiment with twelve boys in the upper 5th form in addition and multiplication. Eighteen exercises were performed in three series of six each. The time for each practice was 10 minutes. Wimms reports that to a limited extent those who work best at addition improve most, and vice versa. He secures in his two experiments coefficients between output of work and improvability of .37 and .33 in addition and .22 and .16 in multiplication. ('07, pp. 163f and 182f.)

Thorndike ('08) conducted an experimental practice in the learning process in which 28 adults multiplied mentally three-place numbers by three-place numbers until 96 problems were multiplied, 5 or 6 being done a day. The results show that "the larger individual differences increase with equal training, showing a positive correlation of high initial ability, with ability to profit by training." ('08, p. 384.)

Thorndike ('10) practiced 19 university students in adding daily for seven days forty-eight columns each of 10 numbers. In this study the initially 6 highest individuals in accomplishment gained 140 problems, the 6 next highest gained 111 problems, while the initially lowest gained 54 problems. ('10, p. 485.)

Whitley ('11) practiced 9 individuals in multiplication of three-place numbers by three-place numbers. By studying the record we find that the four highest made an average gross gain of 403, while the four lowest made an average gross gain of 297. ('11, p. 129.)

Starch ('11) conducted a study in improvement in which 8 adults practiced for fourteen days on mental multiplication. The material of the practice was three-place numbers multiplied by one number. Fifty of these problems were printed on a sheet. The subjects did one sheet of 50 problems a day and recorded the time. The three subjects who stood highest in initial ability gained an average of 45 problems, the three lowest gained 26 problems, each group performing 700 problems in the test. (As reported by Thorndike, '14, p. 306.)

Wells ('12), using 10 adult subjects, who were nurses in the McLean Hospital, practiced 5 minutes a day 6 days in a week for 30 consecutive days on addition and number checking with time variation. The unit of measurement for addition is the number of additions spoken in five minutes, for the number checking test the number of zeros checked in one minute at the average rate maintained in the test. In summarizing the results, Wells states in regard to learning in addition as follows: "In sum, it would then appear from these curves that the amount of absolute gain was for four of these subjects nearly equal in spite of great differences in initial efficiency; the slight difference in absolute gain rather favoring those of greater initial efficiency." Considering the number checking test: "We find that in this function the curves of the differ-

ent men have a tendency to spread out like a fan, with the greatest absolute gain shown by the second subject and the smallest by the subject of lowest initial efficiency." The individual differences in this test among the women subjects turn out so small that not much light on the question is to be derived from the records. On the whole, however, Wells concludes: "We are evidently confronted then with cases indicating a high initial efficiency as a manifestation of superior ability to profit by practice or plasticity; and on the other hand, with cases exhibiting a lower initial efficiency with minor possibilities of practice improvement." ('12, pp. 78-81.)

Thorndike and Donovan ('13) practiced 29 boys in a fourth grade in addition for 30 periods of two minutes each twice daily for the five school days of the week. The lowest initial abilities were 4, 4, 5, 6, 7, 7, 8, 8 examples done correctly; the highest 21, 19, 16, 16, 15, 14, and 14. The first group made an average gain of 7.6 problems correct, the latter 8 problems correct. ('13, p. 426.)

Kirby ('13) conducted an experiment with 1350 children in addition and division in the third and fourth year of the elementary grades. The materials were the Thorndike Addition Sheet and division sheets arranged by the author. The practice was continued for 75 minutes, with an initial practice period of 15 minutes. Kirby does not give the numbers from which the relation of improvement to initial ability is found, but he shows his results graphically. The relationship is positive and significant in amount. We reproduce his curves on page 25.

Thorndike and Hahn ('14) conducted an experiment in which 192 pupils in the 4th, 5th, 6th and 7th grades practiced in adding columns, each of 10 one place numbers, for a period of 90 minutes with an initial and a final practice of 15 minutes. Table 10 on page 26 shows the amount of improvement in problems correct in comparison with initial ability.

They say in regard to the study: "The effect of equal practice upon groups of different initial ability within the same grade is to increase rather than reduce the initial differences. Those who by original capacity or circumstances of training are ahead at the start, maintain and increase their lead." ('14, p. 79).

Brown ('14) and his associates in the psychological laboratory of the University of California instituted an experiment for the study of mutual interference and reinforcement of antagonistic habits.

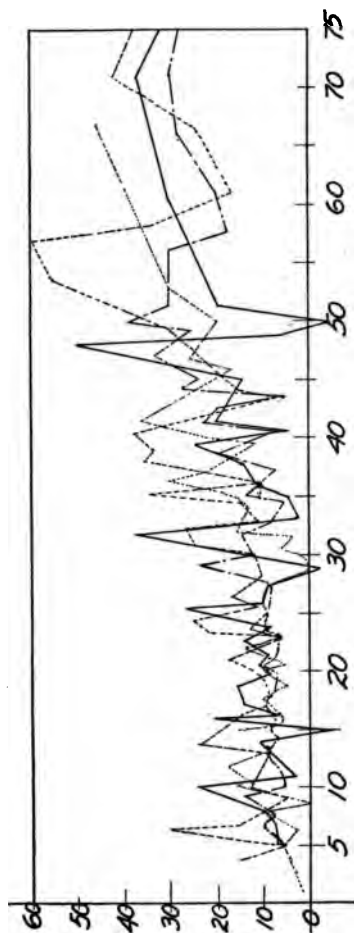


FIG. 1. Improvement in addition in relation to initial ability for each length of practice period. The horizontal scale is for the initial score; the vertical scale is for gain in examples done correctly.

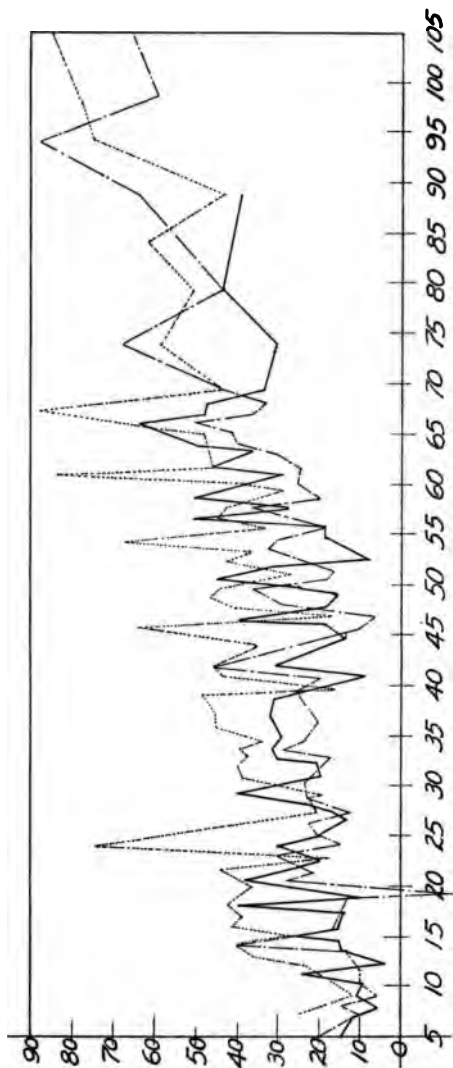


FIG. 2. Improvement in division in relation to initial ability for each length of practice period. The horizontal scale is for the initial score; the vertical scale is for gain in examples done correctly.

From Kirby: *Practices in the Case of School Children*.

TABLE 10
COMPARISON OF INITIAL ABILITY AND GAINS IN ADDITION—THORNDIKE
AND HAHN

Initial Record	Grade 4	Grade 5	Grade 6	Grade 7	Average Gain
0- 6	12.3	10.7	9.0	....	10.7
7-12	7.6	9.7	10.1	15.0	10.6
13-18	13.4	7.6	12.3	17.5	12.7
19-24	6.7	19.5	11.0	20.4	12.3
25-30	....	12.3	1.5	23.4	12.4
31-36	....	54.0	8.5	16.4	....
37-42	....	....	....	9.0	....

The material used was playing cards; the procedure was sorting and boxing the cards. Twenty-six workers practiced on 13 separate days. The first day's work began with boxing the cards, followed by eight successive sortings in the order: diamonds, clubs, hearts, and spades and concluded with a second boxing. This order was followed for eight days' practice. On the ninth day the factor of interference was introduced, in which the order was changed. The speed of work for any given day is the median record for that day expressed by the number of seconds required to sort the fifty-two cards into four suits, plus an allowance of one second for each error. The initial speed and the gain of the highest and lowest quartiles were derived from the original data by the writer and transmuted into records of accomplishment by using the reciprocal. The work of the first eight days was selected as the most useful for our purposes. Table 11 shows the results.

Chapman ('14) obtains the following correlations between initial scores and improvement:

Color.....	.03
Cancellation (2).....	.06
Opposites.....	— .09
Addition.....	.44
Multiplication.....	.28

After explaining small correlations as due to the form of the curve, he makes the statement: "It appears that in complex func-

tions an individual who has gained high efficiency by previous general training will also improve correspondingly during the practice period, whereas in narrow functions initial efficiency probably bears little relation to improvability." He then continues, "If the method of scoring was altered so as to weight improvement which is made as the subject approaches the physiological limit, there is little doubt that high correlations would be obtained in the narrow functions" ('14, p. 39).

TABLE 11

COMPARISON OF INITIAL ABILITY AND GAINS IN CARD SORTING—ADAPTED FROM BROWN ('14, p. 78)

Lowest Quarter		Highest Quarter	
Initial	Gain	Initial	Gain
116	50	166	26
120	72	169	87
126	49	169	23
128	36	172	36
135	28	175	29
135	50	179	38
137	34	192	35
Average: 128	45.6	174.5	39.1

Difference in Improvement -6.5

Thorndike ('15) gave 123 college students practice in multiplication by substitution. The experiment was the same as the one used in this study excepting the time allotment. In his experiment four different forms were used, each one being used three times at a sitting. The average score per unit of time was computed, first for those who in the first trial required under six minutes; second, for those requiring from six to seven minutes; third, seven to eight, etc. The following table shows the results for groups of varying initial ability:

TABLE 12
COMPARISON OF INITIAL ABILITY AND GAINS
Thorndike ('15, p. 431)

		APPROXIMATE PRODUCT PRODUCED PER MINUTE		TIME SPENT IN PRACTICE		
GROUP	NO.	(1) IN FIRST SHEET DONE	(2) IN SHEET DONE AFTER 45 MIN- UTES OF PRACTICE	(3) FROM BEGINNING OF FIRST SHEET TO END OF SHEET REFERRED TO IN COLUMN 2	(4) FROM MIDPOINT OF FIRST SHEET TO MIDPOINT OF SHEET REFERRED TO IN COLUMN 2	(5) GAIN
A	6	15.4	24.2	46.4	42.3	8.8
B	36	12.5	19.4	48.9	43.7	6.9
C	30	10.8	17.3	49.1	43.1	6.5
D	23	9.7	15.1	54.0	47.1	5.4
E	10	8.3	14.5	53.3	45.8	6.2
F	10	7.7	14.4	49.9	41.8	6.7
G	9	6.1	13.6	53.9	44.3	7.5

Thorndike's conclusion is: "In general, the gross improvement in product produced per unit of time is greatest for those of initial highest ability. The effect of equalizing opportunity is to leave the gross variability between individuals unimpaired or even to increase it" ('15, p. 430).

Thorndike ('16) practiced sixty-four educated adults in writing products on a sheet in association with couplets by referring to a key or trusting to memory. The results show marked superiority on the part of the initially highest, as follows ('16, p. 553):

	GAIN
8 Initially Highest.....	15.2
4 Initially Next Highest.....	13.6
7 Initially Next to Lowest.....	9.4
5 Initially Lowest.....	4.7

Peterson ('17), in an experiment in ball tossing, used 28 university students in practice periods until the habit was developed to the extent that the record of 5 days gave no misses. The daily or twice daily practice period was to the accomplishment of 200 catches. The records are in terms of errors and time. The following data are selected from Peterson's tables for the first 30 days

('17, pp. 182 and 184). They show the accomplishment of the upper and lower quarters in errors:

	LOWEST QUARTER						
Initial Score.....	213	209	200	190	174	161	157
Score on 30th day.....	105	100	50	43	15	18	55

	HIGHEST QUARTER						
Initial Score.....	79	72	72	66	64	47	38
Score on 30th day.....	4	10	3	1	4	0	2

The average initial standing of the lowest quarter was 186 errors. The practice of 30 days reduced the average of errors of the same individuals to 55. The average initial record of the upper quarter shows an initial performance of 62 errors. After 30 days' practice the errors of the same individuals were reduced to an average of 3.

Myers ('18) conducted experiments in which 26 normal school students sorted cards for 25 seconds, 20 successive times, during a period of 50 minutes. This was repeated by the same subjects after ten days, then one day later, and finally after an interval of three and one-half months. He secured a correlation between the series of card sorting tests with a class of 16 students as follows:

First with the Last of First Series.....	.31
First with the Last of 10-Day Interval.....	.35
First with the Last of 1-Day Interval.....	.51
First with the Last of 3½-Month Interval.....	.24
Average .....	.35

The subjects maintain their rank through the series with the first five with an average correlation of .47 ('18, p. 318).

Chapman ('19) worked out an experiment in which 20 students participated in a 180-hour experiment in typewriting after 20 hours of initial practice. Chapman takes as one of his problems: "To what extent is it possible from the initial success of an individual in typewriting to predict the degree of success after prolonged training?" The average score of each subject was determined at three periods in the practice experiment. The correlation between the abilities are:

Initial Ability with Final Ability.....	.65
Initial Ability with Intermediate Ability.....	.66
Intermediate Ability with Final Ability.....	.66

The quarter of the group who were highest at the beginning of the experiment made about the same amount of gain as the initially lowest quarter, the average being 172 and 177 respectively ('19, p. 165).

RESULTS OF PRESENT INVESTIGATIONS

Our own experiments have covered a period from 1914 to 1919. They were made with college students and children of the elementary school. The practice of the college students was explained on pages 5 to 12. Ninety-one men and women, mostly of junior and senior standing, practiced addition of one-place numbers, multiplication by substitution, and cancellation of groups of figures containing certain stated numbers. The term of practice was eight periods of twenty minutes each in differing time arrangements for the three experiments designated as Experiments A, B, and C. Tests in each subject of the same content of the practice, but differing somewhat in arrangement, were given at the beginning and close of each experiment. They were addition 1 and 2, multiplication by substitution M and M1, and cancellation 2 and 3, 8 and 9, 4, and 7. The standings of the highest and lowest quarters of the distribution of the initial standing were selected and the gains of the individuals making these standings were compared. The results in product produced per unit of time are shown in Table 13, page 31.

The children who composed the practice group of this part of the study were the forty children of superior intelligence whose work was described on pages 12ff, and children of average ability from the fourth, fifth, and seventh grades of the public schools. The material of the practice and the procedure for the children of average intelligence was identical with that of the children of superior intelligence. The material was addition of one-column numbers, multiplication by substitution, language, history, and the Thorndike Intelligence Tests. The addition practice was 8 minutes a day for 10 days with two initial and two final tests of 4 minutes each; the multiplication by substitution had also two initial and two final tests of 4 minutes each with an intervening practice of

TABLE 13
QUARTILE GROUPING FOR COMPARISON OF INITIAL
ABILITY AND IMPROVEMENT
COLLEGE STUDENTS

	ADDITION			
	BELOW 25 PERCENTILE		ABOVE 75 PERCENTILE	
	INITIAL AVERAGE	GAIN AVERAGE	INITIAL AVERAGE	GAIN AVERAGE
Ex. A.....	13.875	16.00	38.25	26.75
Ex. B.....	13.71	16.28	37.43	18.285
Ex. C.....	16.00	11.12	37.75	11.12
Av.....	14.53	14.466	37.81	18.718

Difference in Improvement..... 4.252

	MULTIPLICATION BY SUBSTITUTION			
Ex. A.....	22.125	82.00	54.75	68.25
Ex. B.....	28.57	47.285	59.86	58.714
Ex. C.....	35.50	48.75	69.00	57.50
Av.....	28.731	59.345	61.203	61.488

Difference in Improvement..... 2.143

	CANCELLATION (2 & 3) (8 & 9)			
Ex. A.....	27.375	24.75	49.625	26.875
Ex. B.....	27.125	24.00	50.86	21.375
Ex. C.....	35.25	17.25	59.37	22.25
Av.....	29.916	22.00	53.285	23.50

Difference in Improvement..... 1.50

	CANCELLATION (4) (7)			
Ex. A.....	87.125	51.25	127.87	48.75
Ex. B.....	86.86	50.00	123.57	35.57
Ex. C.....	87.75	43.50	138.75	51.75
Av.....	87.245	48.25	130.06	45.36

Difference in Improvement..... - 2.89

twenty days for 8 minutes a day. The language tests were the Trabue Scales B and C for initial and Scales D and E for final tests, with a time requirement of 7 minutes each. The practice was the completion of sentences from *Aesop's Fables*. The history tests were the Van Wagenen Thought Scale A with a twenty-day practice on 100 history questions, five questions being used a day. The work with the Thorndike Intelligence Tests was fifteen days' practice with one section of Form A, B, C, D, E, etc.¹

As in the case of the college students, the highest and lowest quarters of the distribution of the initial tests of the children of superior intelligence and of the children of average ability, with the individual gains in each case, were selected for comparison. The results of tests and improvement are given below. To secure the results in Table 14, the children of superior intelligence and the children of average ability were massed in the distribution regardless of intelligence quotients, and the initial standings above the 75 percentile and those below the 25 percentile were selected for comparison. Table 15 gives the comparison of the standings of the extra-quartile grouping of the children of average intelligence alone, and Table 16 of the children of superior intelligence.

TABLE 14

QUARTILE GROUPING OF GAINS: COMBINED GROUP OF CHILDREN OF SUPERIOR INTELLIGENCE AND OF AVERAGE ABILITY

	BELOW THE 25 PERCENTILE		ABOVE THE 75 PERCENTILE		
	INITIAL	GAIN	INITIAL	GAIN	DIFFERENCE IN IMPROVEMENT
Addition.....	5.07	6.69	22.4	9.54	2.85
Multiplication by Substitution.....	36.9	71.1	63.8	90.4	19.3
Language.....	22.3	6.0	32.0	1.83	-4.1
History.....	15.4	10.5	54.5	8.07	-2.43
Thorndike Intelligence.....	57.8	30.9	89.4	22.0	-8.9

¹For complete description see pages 12ff.

TABLE 15

QUARTILE GROUPING OF GAINS: CHILDREN OF AVERAGE INTELLIGENCE

	BELOW THE 25 PERCENTILE		ABOVE THE 75 PERCENTILE		DIFFERENCE IN IMPROVEMENT
	INITIAL AV.	GAIN AV.	INITIAL AV.	GAIN AV.	
Addition.....	4.3	6.3	22.0	7.6	1.3
Multiplication by Substitution.....	33.0	69.4	62.7	68.5	-0.9
Language.....	18.7	6.75	32.2	0.	-6.75
History.....	12.1	7.9	50.8	6.3	-1.6
Thorndike Intelligence.....	42.8	32.8	65.0	28.0	-4.8

TABLE 16

QUARTILE GROUPING OF GAINS: CHILDREN OF SUPERIOR INTELLIGENCE

	BELOW THE 25 PERCENTILE		ABOVE THE 75 PERCENTILE		DIFFERENCE IN IMPROVEMENT
	INITIAL AV.	GAIN AV.	INITIAL AV.	GAIN AV.	
Addition.....	7.66	7.55	24.11	15.00	7.45
Multiplication by Substitution.....	41.70	79.50	65.4	117.9	38.4
Language.....	24.2	6.4	31.5	2.4	-4.0
History.....	27.0	15.5	57.1	8.8	-6.7
Thorndike Intelligence.....	72.4	28.0	115.8	16.0	-12.0

It appears that the initially superior in addition and substitution made greater gross gains. In the other abilities measured, however, the initially low made larger gross gains. Only a rather moderate allowance for the greater value of the same gross gain at the higher levels of practice, and for the approach to a physiological limit, is required to credit the initially superior with greater real gains than the initially low. On the whole, then, our findings are

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in fairly close accord with those of previous students; and all indicate that the ability possessed by any person at any time is, in a large measure, a product of what native capacity he has and a prophecy of what further improvement he will make from a given amount of practice.

CHAPTER III

THE RELATION OF IMPROVABILITY TO GENERAL ABILITY

RESULTS OF PREVIOUS INVESTIGATIONS

Studies of this subject have been made by Norsworthy ('06), Colvin ('15), Ordahl and Ordahl ('15), Strong ('17), Woodrow ('17), and Murdoch ('18).

Dr. Norsworthy conducted extensive tests comparing feeble-minded and normal children. She described her tests as follows: "Tests of Efficiency of Perception, marking *a*'s on a printed page; Memory of Related Ideas, related words pronounced; Ability in Formation of Abstract Ideas, noun test; Ability to Appreciate Relationship and Control Association, opposites test; Perception of Weights and Motor Control, maze and form board."

About one year afterward the same tests were repeated for both defectives and average children in order to see what changes had taken place. Dr. Norsworthy's findings are quoted in Table 17, and her conclusions derived from them.

Dr. Norsworthy's conclusions are: "Comparing the amounts of improvement of the feeble-minded and the nine-year old children, we find that in two of the maturity tests¹ the defectives improve more than the normals, namely, in "A" tests and in the memory of unrelated words in which the respective ratings are 7.7 and 5.0 and 1.7 and -1.0. In the rest of the maturity tests, the ordinary children improved more than the defectives. In the tests of memory,² including the dictation work, the defective children improve much more than the other children, for their total record gives a change of 4.4 and that of the others only 0.3. . . . In the intelligence tests,³ the greater improvement is with the

¹ Dr. Norsworthy's maturity tests were the "A" and the *a-t* tests which were the marking of words containing the letter *a*, and *a-t* respectively, the weight test, which was the filling of boxes with weights to equal a box weighing 100 grams, and the memory of unrelated words.

² The memory tests were memory of sentences and memory of related words.

³ The intelligence tests were the naming of opposites, the genus-species, and the part-whole tests.

	INITIAL ERRORS	GAINS IN ERRORS
Six	8.4	-0.5
Eight	5.3	-2.5
Ten	3.4	-1.8

The experiment in judgment of sizes was in content and procedure the same as judgment of form excepting that the sizes were different. The scores are also given in the average daily errors.

	INITIAL ERRORS	GAINS IN ERRORS
Six	19.9	-0.9
Eight	11.8	-2.8
Ten	8.7	-4.7

In judgment of form for three dimensions, twenty wooden blocks were cut out, ten with dimensions 2 in. by 2 in. by 2 in.; ten, 3 in. by 2 in. by 1 in. These blocks were then shaped into a series of forms somewhat like the forms of the preceding experiments. The same procedure controlled as in the preceding experiment, except that the blocks were held stationary. At the end of five days the gain in initial ability was as follows:

	INITIAL	GAINS IN ERRORS
Six	15.7	-0.5
Eight	11.0	-5.2
Ten	5.8	-3.7

The modified typewriting experiment was an endeavor to develop a connected series of visual motor coördinations. The apparatus used was a typewriter of four keys, each of which was a different color. When a key was pressed, a different color, which was the color of the next key to be struck, appeared above it. The keys were connected with electrical counters for signals and registration. "The problem involved a series of four motor reactions to specific visual cues."

The results show initial ability in comparison with gains in terms of correct responses:

	INITIAL RESPONSES	GAINS
Six	22.7	32.1
Eight	45.1	100.2
Ten	80.7	199.0

The results of these experiments by Ordahl and Ordahl show that in the activities involving visual attention, judgment of form and size, and visual motor coördinations, the feeble-minded improved with practice in these learning processes, and that the feeble-minded of eight and ten year mentality showed marked superiority in improvement over those of six year mentality. ('15, pp. 15, 23, 24, 25, 33.)

It should be noted that, since the chronological ages are all above fifteen, the intelligence quotients of the three groups would be in approximately the proportions 6, 8, and 10.

Whether or not we decide that those of mental age ten improved much more than those of mental age eight will depend upon our judgment of the amounts of improvement shown in the above data. In the actual gross gains there is little difference, except in the modified typewriting, where those of mental age ten are clearly superior. But if we assume that the same gross gain means more improvement when it is added to an already high degree of ability than when it is added to a lower, those of mental age ten make markedly greater improvement throughout.

Strong ('17). E. K. Strong, Jr., practiced normal and sub-normal children of the same age 14 days, 2 minutes a day, in simple addition combinations. The normal children advanced from 38 to 66 such combinations, the sub-normal, after 25 days' drill by an experienced teacher, advanced from 15 to 22. Two of the children of the latter group were not defective. ('14, p. 153.)

Woodrow ('17) made a study of practice and transference in normal and feeble-minded children of the same mental age. The practice work was geometrical form sorting, consisting of sorting gun wads on which were printed labels bearing the outlines of simple geometrical forms. There were five kinds of forms to be sorted into appropriate boxes. The question was whether the feeble-minded would show the same improvement with practice. Quoting the report of Woodrow, "The question from whatever angle studied must be answered in the affirmative. . . . Upon computing the averages of the percentages of improvement shown by the individuals of each group, we obtain an average of 49 for the feeble-minded and one of 46 for the normal. In both groups the linear correlation between the initial abilities of the children and the percentage of improvement is negative, the correlation being

-.36 (P. E., .13) for the feeble-minded and -.40 (P. E., .14) for the normal group. If instead of computing the correlation between initial ability and percentage of improvement, we compute that between initial ability and absolute improvement, we find in the case of both groups that the correlation remains negative but becomes very small and unreliable, changing for the feeble-minded group from -.36 to -.13 (P. E., .15) and for the normal group from -.40 to -.11 (P. E., .17) ('17, pp. 93 and 94.)."

Murdoch ('18) compared the rate of improvement of a group of feeble-minded children and scale ratings of normal children. There was no practice procedure except that obtained in the ordinary routine of school activities. The tests were given to the same children with a period of one year's time in the interim. The comparison is made between the actual improvement of the feeble-minded as measured by the scales used, and the difference between the standards of the same scales for the two years considered. The facts shown in Table 18 were obtained.

After a comparison of the work of the groups, Murdoch makes the following statement: "Our data seem to point unreservedly to one conclusion which is that the rate of learning of feeble-minded children in these elementary school subjects is less than the rate of normal children at the same level."

RESULTS OF THE PRESENT INVESTIGATIONS

The problem in this study involves the improvability of children of superior intelligence in comparison with children of average ability, about two and one-half years older chronologically, but of somewhat lower mental ages. The children of superior intelligence were in two classes, designated as S I and S II. Eligibility for membership in the classes was determined by the Binet-Simon tests for intelligence. The lower limit of the requirement for membership was an intelligence quotient of 124. The range of intelligence quotients was from 124 to 180. The average chronological age of Classes S I and S II, at the time the experiments were made, was 9.5 years. The average intelligence quotient was 144.

The control groups with which the comparison was made consisted in all of 172 children. The average chronological age of the fourth and fifth grade groups at the beginning of this practice was

10.9 years, and that of the seventh grade groups was 13.5 years. These children were not measured for intelligence.

The data used in this section are the results of the practice of children of superior intelligence described in Chapter II and the work of the control group on the same material.

TABLE 18
COMPARISON OF RATE OF PROGRESS BETWEEN TWENTY-ONE FEEBLE-MINDED
SUBJECTS AND NORMAL CHILDREN
—Murdoch ('18, p. 295)

FACTORS MEASURED	CLASS 1917	AVERAGE 1918	IMPROVE- MENT OF FEEBLE- MINDED	NORMS		IMPROVE- MENT OF NORMALS
				GRADE 3	GRADE 4	
Chro. Age (range 12 yrs.—23 yrs.).....	16-4	17-4		9-2	10-2	
Mental Age (range 7-6 to 11-1).....	9-2	10-0	10 mo.	9-2	10-2	12 mo.
Intelligence Quotient..	.6066	.6442	.0376	1-0	1-0	0
Sylvester Form Board	19.309	20.214	-.905	18-7	16-7	2.0
Trabue Completion Test, Scale B.....	9.8	9.0	-.8	6.0	8.0	2.0
Thorndike Visual Vo- cabulary.....	4.27	4.70	.43			
Thorndike Reading Scale, Alpha 2.....	5.3019	5.459	.1571	5.25	5.75	.5
Woody, Addition....	10.4	11.8	1.4	9	11	2.0
Woody, Subtraction..	8.0	8.3	.3	6	8	2.0
Woody, Multiplication	7.52	9.04	.152	3-5	7	3-5
Woody, Division.....	4.7	5.8	1.1	3	5	2.0
Ayres, Spelling List T	40.9	41.7	.8	50	60	10.0
Thorndike Handwrit- ing Scale.....	9.78	9.66	.12	9	10	1.0
Hillegas Composition Scale.....	30.65	31.65	1.0		35	
Woodworth-Wells, Easy Opp., (time 1' 45'').....	12.25	14.95	2.675			
Thorndike Drawing Scale.....	5.9	6.59	.69			
Woodworth-Wells, Adj. Nouns (time 1' 45'').....	9.71	12.368	2.658			

EXPERIMENT A**ADDITION**

The daily average scores and the sum of the initial and final tests, in averages, in addition for the Classes S I, S II, and control group are:

CLASS S I											
TEST	PRACTICE										TEST
I & II	Tues.	Wed.	Thur.	Fri.	Mon.	Tues.	Wed.	Thur.	Mon.	Tues.	I & II
13.3	18.1	18.6	20.8	23.7	21.6	23.1	25.5	26.3	24.7	25.1	22.2

CLASS S II											
21.5	20.8	24.5	25.9	27.6	28.0	27.7	33.2	34.3	34.5	34.7	31.4

CLASS S I AND CLASS S II COMBINED											
16.8	19.4	21.1	23.0	25.3	24.3	25.1	25.8	29.6	28.8	29.2	26.1

CONTROL CLASSES FOURTH GRADES											
12.4	15.5	17.7	17.2	16.7	18.9	18.2	18.6	18.3	19.0	20.0	17.8

The curves in Fig. 3 (page 43) show the improvement of the three groups graphically. The distribution of gains in addition in general is shown in Table 19 (page 44).

The results of the class practice in test averages in addition for the comparison of the groups under consideration are:

CLASSES	INITIAL SCORE	FINAL SCORE	GAIN
S I.....	13.3	22.2	8.9
S II.....	21.5	31.4	9.9
S I and S II.....	16.8	26.1	9.3
Control.....	12.4	17.8	5.4

The children of superior intelligence thus gained 72.2 per cent more than did the average children.

In order to free the comparison from differences in initial ability in addition, 36 out of the 38 children of superior intelligence were paired with 36 out of the 72 control group, who had approximately

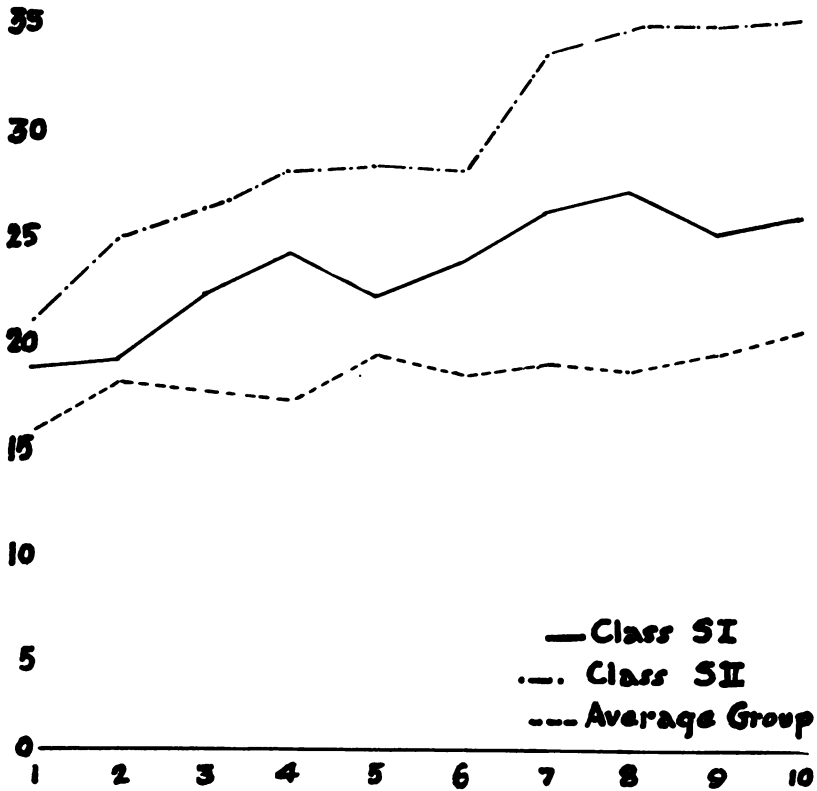


FIG. 3. Comparison in Addition. Children of Superior Intelligence and Average Ability.

the same initial test scores. All cases that could be paired were paired. To illustrate:

CHILDREN	INITIAL SCORE	FINAL SCORE	GAINS
A B of Class S I.....	14	24	10
C N of Control.....	14	21	7

The class scores in averages of problems right, paired for initial ability are:

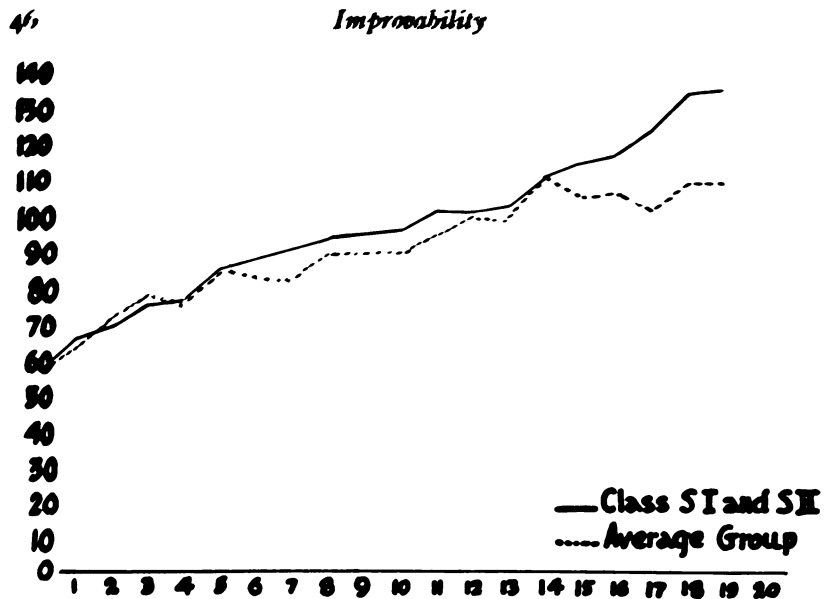


FIG. 4. Comparison in Multiplication by Substitution. Children of Superior Intelligence and Average Ability.

Considered in general, the average gain of the children of superior intelligence over the average of the control group in multiplication by substitution is 22.6 couplets correct, or 34 per cent.

In order to free the comparison from differences in initial ability in multiplication by substitution, 37 out of the 40 children of superior intelligence were paired with 37 out of the 53 in the control group who had the same or nearly the same initial score. All cases which it was possible to pair for like initial ability were paired. The initial and final average scores with gains for these 37 pairs are:

CLASSES	INITIAL SCORE	FINAL SCORE	GAINS
S I and S II.....	53.9	142.9	89
Control.....	52.9	117.1	64.2

The gain of the superior intelligence group over the control group is 24.8 couplets correct, or 38.6 per cent.

TABLE 20

DISTRIBUTION OF GAINS IN MULTIPLICATION BY SUBSTITUTION IN GENERAL

GAINS	CLASSES S I AND S II	CONTROL
20	-	1
25	-	1
30	3	-
35	2	2
40	6	5
45	4	4
50	-	7
55	1	1
60	4	4
65	-	8
70	1	3
75	2	1
80	2	4
85	1	2
90	1	2
95	-	2
100	1	1
105	-	2
110	1	1
115	1	-
120	-	-
125	2	1
130	-	-
135	-	-
140	-	-
145	-	-
150	2	-
155	-	-
160	-	-
165	1	-
170	-	-
270	1	-

Average Gain of Classes S I and S II.....89.0

Average Gain of Control Group.....66.4

EXPERIMENT D

REASONING PROCESSES IN UNITED STATES HISTORY

The personnel of this experiment was the two classes of children of superior intelligence, Class S I and Class S II, together numbering 42, with an average age, at the time of the experiment, of 9.8. The control group was made up of two classes of 7B children with an average age, at that time, of 13.5 years. The number of children in this group was 68.

The practice consisted of thought questions in United States history, as described on pages 14ff.

The practice results for Classes S I and S II and the control groups of Classes 7B¹ and 7B², with the initial and final test scores, are:

TESTS					PRACTICE									
History					1	2	3	4	5	6	7	8	9	10
Classes S I and S II.	43.3	—6	7	12	11	10	9.5	10	10	10.5	11			
Control.....	31.1	—6	5.5	9.5	10	7.5	8.5	9	7.6	9	9.5			
II	12	13	14	15	16	17	18	19	20					TESTS
II	11	10	11	11	12.5	10	9	10.5	9					56.6
10	8.4	8.4	10	10	9.1	8.2	6.6	7.6	6.3					40.8

Classes S I and S II made average gains from the beginning test of 43.3 to the final test of 56.6, of 13.3 points. The control classes made average gains from the beginning test of 31.1 to the final test of 40.8, of 8.7 points.

Table 22 gives the distribution of gains for Classes S I and S II and for the control groups in general.

The average initial, final, and gain scores for reasoning in history are:

CLASSES	INITIAL	FINAL	GAIN
Classes S I and S II.....	43.3	56.6	13.3
Control.....	31.1	40.8	9.7

There is thus a difference of 38 per cent. in favor of the group of children of superior intelligence.

TABLE 22
DISTRIBUTION OF GAINS IN REASONING IN HISTORY: GENERAL

GAIN	CLASSES S I AND S II	CONTROL
-8	-	3
-6	-	2
-4	-	1
-2	-	4
0-1	-	1
0+1	1	7
2	4	5
4	1	1
6	3	3
8	4	6
10	1	8
12	10	4
14	2	3
16	2	1
18	2	3
20	1	1
22	5	4
24	2	1
26	-	3
28	1	2
30	-	-
32	-	-
34	-	3
Gain	13.3	9.7

That the comparison might be free from the influence of differences in initial ability, members of Class S I and Class S II were paired with members of the control group for initial like scores, 33 out of the 42 members of Classes S I and S II being paired with 33 members out of 51 members of the control group. As always, all the initial scores capable of pairing were paired for like associates.

The average initial and final test scores and the gains in reasoning processes in history, the pupils being taken in pairs equal in initial ability, are as follows:

CLASSES	INITIAL	FINAL	GAIN
Classes S I and S II	41.0	55.0	14.0
Control	40.4	50.7	10.3

The final test score of the children of superior intelligence exceeds the final test score of the control group by an advantage of 3.7, or or 35 per cent.

EXPERIMENT E

THORNDIKE INTELLIGENCE EXAMINATION FOR HIGH SCHOOL GRADUATES

The practice continued 15 days, 30 minutes a day. There were no end tests. The score was that regularly used in the examination. The distribution of gains is shown in Table 23. Fig. 5 portrays graphically the general course of practice for the two groups.

As shown in Fig. 5, the ranking difference between the two groups is maintained approximately the same from the beginning, with the children of superior intelligence starting and closing the practice at a much higher level than that of the average children. As the practice continued, the average children made somewhat larger gross gains, but not enough larger to reduce notably the difference between the two groups. The pairing so as to eliminate the influence of differences in initial ability in the function itself could not be done in this case, only one of the normal group being equal to any in the superior group.

It seems that the results of our experiments are at variance with Woodrow's idea that feeble-minded children show as great a degree of improvability as normal children of the same mental age. Perhaps Woodrow's tests were ineffective in measuring the improvability of normal children because of the accumulative dissatisfaction which would accrue to normal children in an extended sorting of symbolically marked gun wads.¹ The abilities he tested were of a rather unintellectual sort. Our results are in accord with those of Norsworthy, Strong, Colvin, Murdoch, and the Ordahls.

¹ From the sixth to the thirteenth periods inclusive of the test of the average children by Woodrow's graph a decided plateau is shown.

TABLE 23

THORNDIKE INTELLIGENCE EXAMINATION. DISTRIBUTION OF GAINS

	CLASSES S I				CONTROL			
	I to 2	I to 3	I to 10	I to 15	I to 2	I to 3	I to 10	I to 15
-2	-	I	-	-	I	I	-	-
0-2	-	-	-	-	-	-	-	-
0+1	-	-	-	-	-	-	-	-
2	I	-	-	I	I	-	-	-
4	2	-	-	-	-	-	-	-
6	I	-	I	I	I	-	-	-
8	I	-	-	2	-	I	-	-
10	2	-	-	2	-	-	-	-
12	3	I	I	2	-	3	-	I
14	2	3	2	I	I	3	-	I
16	-	3	I	I	3	I	I	-
18	-	I	2	-	2	2	3	-
20	3	-	I	I	I	-	-	-
22	-	3	-	-	-	I	I	I
24	2	2	I	I	-	2	2	-
26	I	I	-	4	4	2	-	-
28	-	-	3	I	-	2	-	4
30	-	I	-	-	I	-	I	-
32	-	-	I	-	-	-	I	I
34	I	I	I	-	I	-	I	2
36	-	-	-	I	I	-	3	2
38	-	I	2	-	-	-	I	2
40	-	I	-	-	-	-	I	I
42	-	-	-	I	-	-	2	I
44	-	-	I	-	-	-	-	I
46	-	-	-	-	-	-	-	-
48	-	-	-	-	I	-	-	-
50	-	-	-	-	-	-	-	-
52	-	-	I	-	-	-	I	-
54	-	-	I	-	-	-	-	-
56	-	-	-	-	-	-	-	-
	14.8	21.7	27.5	19.1	19	16.7	30	31

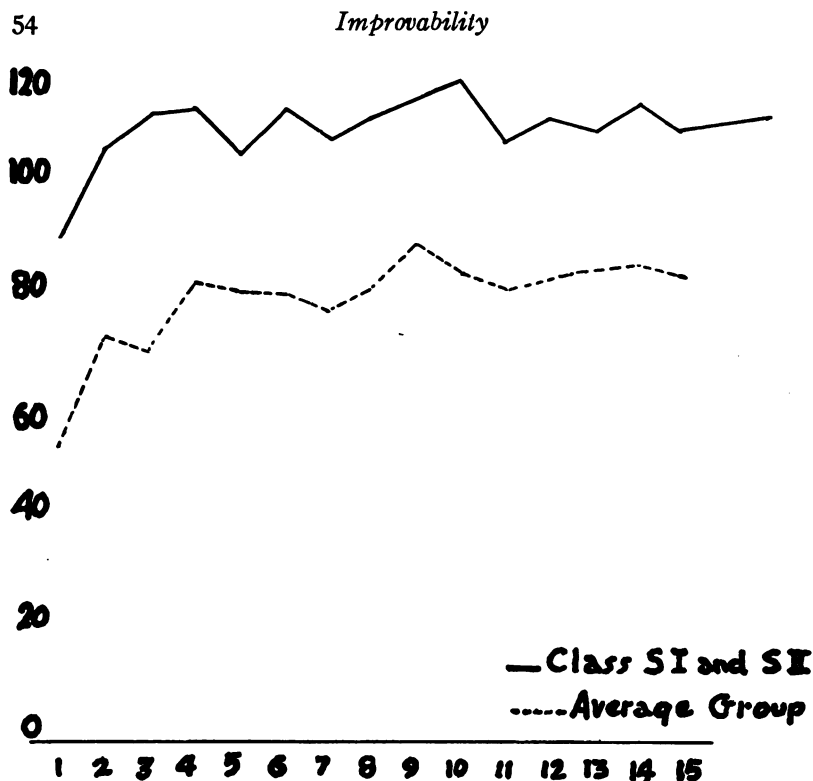


FIG. 5. Comparison of Improvement. Thorndike Intelligence Examination. Children of Superior Intelligence and of Average Ability.

We infer from the investigations of this research that varying mental levels yield, in general, differences in improvability, the higher levels producing the greater improvement. Low grade feeble-minded learn at a slower rate than higher grade feeble-minded and both of these grades at a slower rate than normal children. Extending our research higher in the scale of ability, we find that children of superior intelligence show greater improvability than average children and that in the higher ranks of the gifted, the greater the general ability the greater the learning achievement. Both the chronological and mental ages must enter into the consideration of the learning process. In brief, improvability correlates positively with the intelligence quotient.

CONCLUSIONS

Improvability is specialized. Different mental functions show different degrees of learning. While the rapid learner in one field learns rapidly in all fields, his improvement is greater in some functions than in others.

In the relation of improvability to initial ability in the function itself, we find that the measure of initial ability is a measure and a prophecy of improvement, that native capacity in any function determines what shall be accomplished by that function.

In the relation of improvability to general ability, the more superior the general intelligence, the more significant the learning process.

APPENDIX I

Appendix I is a collection of samples of the materials used in the practice described in the foregoing experiments.

ADDITION PRACTICE

2

3	5	8	6	7	8	6	8	7	7	2	5	8	6	6	3
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5	7	6	6	9	9	8	8	7	6	6	5	8	5	2	9

5	6	7	4	9	4	2	4	2	3	9	6	7	7	3	4
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7	2	6	3	2	9	3	2	6	4	3	9	8	8	9	9
3	7	9	2	6	5	8	6	9	9	2	7	3	5	6	4

SUBSTITUTION PRACTICE

L.

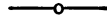
13 19	14 11	15 15	17 11	19 15
16 11	11 19	12 17	12 14	18 18
18 19	15 13	16 17	13 15	14 17
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12 13	12 18	13 14	15 14	12 15
16 15	13 17	15 11	11 17	13 16
14 15	16 18	11 13	14 19	12 11
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11 11	14 16	16 14	18 14	19 16
13 18	18 12	11 16	13 13	14 14
11 15	15 16	14 13	12 16	15 19
15 18	17 17	19 18	16 19	16 12
19 14	13 12	15 12	19 11	17 19
13 11	16 13	17 13	14 12	18 11
19 19	11 14	18 15	12 19	19 13
18 16	17 18	11 18	18 13	19 17

LANGUAGE PRACTICE

66

ÆSOP'S FABLES.

difficulties to annoy them; but the time will come when they will repent them of their insolence.



MERCURY AND THE WORKMEN.

A WORKMAN, felling wood by the side of a river, let his axe drop by [redacted] into a deep pool. Being thus deprived of the means of his livelihood, he sat down on the [redacted], and lamented his hard [redacted]. Mercury appeared, and demanded the [redacted] of his tears. He told him his misfortune, when Mercury plunged into the stream, and, bringing up a golden axe, inquired if that were the one he had lost. On his saying that it was not his, Mercury disappeared beneath the water a second time, and returned with a silver axe in his hand, and again demanded of the workman "if it were his." On the workman saying it was not, he dived into the pool for the third time, and brought up the axe that had been lost. On the workman [redacted] it, and [redacted] his joy at its recovery, Mercury, pleased with his [redacted], gave him the golden and the silver axes in addition to his own.

The workman, on his return to his house, related to his companions all that had [redacted]. One of them at once resolved to try whether he could not also secure the same good [redacted] to himself. He ran to the river, and threw his axe on purpose into the pool at the same place, and sat down on the bank to weep. Mercury appeared to him just as he hoped he would; and having [redacted] the cause of his grief,

CANCELLATION PRACTICE

983642	168379	694517	253914	745682	158923	729648
426357	372159	754936	297835	627519	786531	731469
654173	947386	589761	134852	146237	194526	936425
837162	691324	814536	326175	368792	549826	572194
458671	971648	479612	495688	764295	817243	916328
275148	318495	635728	596873	982563	431289	381647
513978	182765	615632	851279	498136	356719	412789
197584	563792	748315	861395	421856	973124	125437
918654	846975	453867	281463	213956	651274	526987
397841	961872	248691	574389	532416	723964	473519
872351	327084	437528	864712	825916	682543	534169
923871	632791	765429	235849	672834	295481	349257
867314	462758	486592	198537	871596	164985	247153
963458	981374	156843	259671	762491	983567	579361
345962	941258	182653	561487	435781	179428	731825
672389	346521	427163	281937	672539	985273	956142
312876	853926	587436	296851	784623	875126	513647
934612	739548	843216	215367	916483	294378	768914
954178	371629	529817	436978	123874	957641	682917
719325	294736	639187	286415	593182	297568	145389
594231	389254	196235	825749	461289	378652	672841
349716	427395	138962	268794	524617	358472	319546
714932	759431	382145	853624	714529	635819	237465
649752	718254	596743	862934	851763	329418	495867

HISTORY

PRACTICE TEST QUESTIONS

1. Three hundred years ago a body of men in England tried to obtain a free church and liberty to worship God as their conscience dictated. Many of these men were among England's most able citizens. They were persecuted by the ruling power so severely that some of them left their native land and went to Holland. They settled at a town called Leyden and lived there for several years in peace. Later these people became known as Pilgrims.

a. *What kind of government and what kind of ruler do you think England had at that time?*

b. *What kind did Holland have?*

2. At that date, Leyden was a manufacturing city as large as London was. There the Pilgrims obtained work as weavers, tailors or carpenters. In England many of them had been farmers. They found, of course, that the Dutch language, customs and religion prevailed at Leyden.

In this situation, what advantages did America offer the Pilgrims?

3. After the Pilgrims had lived at Leyden for a few years, they discovered that their children were learning many of the Dutch customs. Soon after they had realized this, they began to make plans for migrating to America.

What do you think they feared for the future?

4. Steamboats had not yet been invented. The Pilgrims started for America in two sail boats, the Mayflower and the Speedwell. The Speedwell, said to be unseaworthy, was taken back to port and they continued the voyage on the Mayflower alone. It took nine weeks to cross the Atlantic to a wild, unsettled and strange country.

Underscore three words which in your opinion describe the character of these people: Cowardly, courageous, selfish, devoted, shiftless, patient, daring, hopeless, foolish, timid, reckless, persevering.

5. In England the people who sought to purify the church were called Puritans. Those who left altogether were called Separatists.

Were the Pilgrims Puritans or Separatists?

6. The London and Plymouth Companies were trading companies of English merchants which had obtained large grants of territory in America from the English King. The London Company lent the Pilgrims money for their expenses.

Why do you think these merchants gave the grants and lent the money?

7. The Pilgrims were forced to borrow money for the expenses of their expedition. All of their number could not go to America, so some remained in Holland. The Speedwell, which left Delft Haven, Holland, in 1620, was joined by a large vessel, the Mayflower, at Plymouth, England. The Speedwell leaked and had to return twice, and finally was forced to discontinue the journey, turning over its passengers to the Mayflower on Sept. 6, 1620. The boat was crowded with her 102 passengers and reached the Harbor of Provincetown on Nov. 21.

a. *What can you say of the financial conditions of the Pilgrims?*

b. *How did the Mayflower compare with our modern steamers in size and speed?*

8. While on board the Mayflower, many difficulties arose. The journey was long and stormy. Day after day, high winds tossed the frail bark on the ocean, tore the sails, and threatened to overturn it.

Underscore the three words which you think expressed their feelings: Joyous, brave, carefree, undaunted, happy, undismayed, frightened, downhearted.

9 and 10. Before the Pilgrims landed they met in the cabin of the *Mayflower* and made a compact stating that they had undertaken the voyage for the glory of God, the advancement of the Christian faith and in honor of their king and country. They declared: "We do solemnly and mutually in the presence of God and one another covenant and combine ourselves together into a civil body politic for our better ordering and preservation, and the furtherance of the end aforesaid and by virtue hereof to enact, constitute and frame such just and equal laws as shall be thought most meet and convenient for ye general good."

a. Which statement shows loyalty to England?

b. Which two statements show a belief in democracy?

11. After signing the compact and after John Carver had been made Governor, the *Mayflower* rounded the cape and found shelter in the quiet harbor where Provincetown is now located. On that same day an armed party of men rowed ashore. They found no Indians and no attractions for a permanent settlement there. Some days were spent in exploring Cape Cod Bay and finally Plymouth Harbor was chosen.

State three things that the Pilgrims would look for in selecting a place to settle and build their homes.

12. The *Mayflower* came to anchor at Plymouth Harbor, December 16th. The first house was begun the next week and soon all had homes. They had been used to the milder climate of England; the log houses did not protect them very well against the cold; their food supply was low.

What results would you expect from these conditions?

13. After the *Mayflower* came to anchor the women, children and sick remained for several weeks on board ship.

Give two reasons why this was a good plan.

14. The first Monday after the Pilgrims landed the women and boys went ashore, built fires of great logs and branches, brought ashore tubs and boilers from the ship and had a great wash day.

Underscore three words that describe the character of the women: Lasy, negligent, industrious, capable, cleanly, foolish, improvident, slovenly.

15 and 16. Within four months after the landing, sickness carried off nearly half of the Pilgrims. Six died in December, eight in January, seventeen in February, and thirteen in March. At one time, during the winter, only six or seven had strength enough left to nurse the dying and bury the dead. They were crowded in the ship or half built cabins heaped with snow drifts. Their food was not the best for sick people. The sailors on the *Mayflower* refused them even a share of the sea stores which would have helped. Finally some of the sailors became ill and the Pilgrims, forgetting the way they had been treated, helped take care of the sick seamen. Then the sailors changed their way of doing and shared their food.

a. Underscore three words that show the character of the sailors: Generous, selfish, good, cruel, rude, wise, kind, friendly.

b. Underscore three words that show the character of the Pilgrims: Generous, stingy, silly, weak, selfish, forgiving, careless, patient.

17. The Pilgrims buried those who died during the winter on a bluff by the ocean shore. In the spring they planted corn on the graves. They believed that the Indians would not attack a colony that they thought to be a large one.

Why did the Pilgrims plant corn on the graves?

18 and 19. The Pilgrims had left England and wandered to Holland. They finally

came to America in order that they might have a church, pure in worship and a people devoted to God and religion. In 1622 Thomas Morton, with a company of men and women, came to Massachusetts and made a settlement at a place they named Merry Mount. These new comers were followers of the king and members of the established church of England. They sold guns, ammunition, and rum to the Indians.

Morton's settlement finally broke up and the settlers went back to England.

a. How would you expect the Pilgrims to feel toward the Merry Mount settlers?

b. How do you think the Pilgrims felt over their departure?

20. The Pilgrims at first worked together on the company lands, no man worked for himself, but each one for the company in general. Finally the governor, at the earnest request of the Pilgrims, allotted to each man a portion of ground. He wrote afterwards, "This had very good success for it made all hands very industrious."

Why did the governor's action make them all very industrious?

21. The grant owned by the London Company was from 34 to 38 degrees north latitude. The grant of the Plymouth Company extended from 41 to 45 degrees north latitude. The London Company gave the Pilgrims permission to settle somewhere in their territory in Virginia. However, the high winds drove the Pilgrims farther north into Massachusetts somewhere near 42 degrees north latitude.

Before the Pilgrims had the right to stay there, what was necessary for them to do?

22. The Pilgrims owed the English Company over 1,000 pounds, which would be about \$5,000 in our money. They hoped to trade with the Indians in order to make this amount. They had little English money, besides what they had could not be used very well with the Indians. The colonies had used corn as money for a time but this they desired to plant or use for food. Shells called wampum were used by the Indians for money.

What would you expect the Pilgrims to adopt for money for a time at least?

23. A plague had destroyed the Indians that had lived where the Pilgrims settled. The Pilgrims, however, found some corn that the Indians had buried. This was of little value to them at that time as they had never seen corn raised and knew very little about it. One morning a solitary Indian named Squanto suddenly appeared in the colony to the great surprise of the settlers. Later he brought his chief Massasoit and an important treaty was made which lasted 50 years.

Why were the colonists surprised at the appearance of Squanto?

24. *Give three reasons to explain why Squanto's coming was an advantage to the colonists.*

25. *What two things could an Indian teach the settlers?*

26. Charles I reigned as King of England from 1625 to 1649. Early in his reign, he dissolved the English Parliament, which is the English law making body. He also persecuted, imprisoned and fined those who were leaders in an effort to secure religious freedom. The years from 1630 to 1640 were known as the years of great Puritan migration to America.

What were two great reasons for the migration?

27. Among the first of those to leave England at this time was a group of 840 English Puritans. They came in a fleet of fourteen boats in 1630. Many of

them were men and women of wealth, refinement and prominence in England. They founded Boston, Salem, and other towns in Massachusetts.

In what two ways did they differ from the Pilgrims who settled at Plymouth?

28. These Puritans held a charter from the King, which provided that all laws of the colony should be made by vote of the freemen in the colony. This voting was done by each member in the town meetings. In a republican form of government, the people elect representatives to vote for them. In the purely democratic government, each man votes for himself.

Was the town meeting of Massachusetts democratic or republican in form?

29. The following statement is taken from the old records of the town meeting in Massachusetts. It is dated 1635, fifteen years after the Pilgrims landed and five years after Boston was founded: "At a general meeting upon public notice it was generally agreed upon, that our brother Phileman Pormort shall be entreated to become school master for the teaching and nurturing the children among us." Harvard College was founded the next year.

In 1647 the general court passed what is called the charter of free education. It is as follows: "That learning may not be buried in the graves of our fathers in church and common wealth, the Lord assisting our endeavors, it is therefore ordered that every township in this jurisdiction, after the Lord hath increased them to the numbers of fifty householders, shall then appoint one within each town to teach all such children, as shall resort to him, to read and write."

What advantage in education did the Puritans believe should be given to the children? How many children were given this advantage? How do these laws show democracy?

30-32. A Dutch visitor described the Plymouth colony when it was 7 years old. He said that the houses of good-hewn plank stood in little gardens along the streets. At the top of the hill there was a square, strong building in which the Pilgrims held their church meetings and town meetings about the business and government of the colony. On the top of this house, there were six cannon so placed as to command the country and harbor. When the Pilgrims went to church or town meetings they carried with them their matchlock or flintlock guns. These were very unlike the firearms in use today. The powder in the matchlock had to be lighted from a burning fuse; the flintlocks had flints which struck fire by hitting against a piece of steel and so set fire to the powder.

The people had found out what sort of crops to raise and how to raise them on the poor, stony soil. They established fisheries along the coasts and trading posts among the Indians. Ships that brought supplies and colonists from England were sent back laden with lumber, salt, fish, and furs.

a. What kind of relations do you think existed between the Pilgrims and the Indians at that time?

b. How did their means of protection and warfare compare with ours of this modern date?

c. What do you suppose the English people thought of the colony and colonists?

d. Underscore four words descriptive of the colony after seven years: Successful, fruitless, prosperous, worthless, thriving, valuable, fruitful, unsuccessful, failing.

33. The Puritans cared more for their religion than for anything else. They had given up their homes, many of their friends, in fact everything that was dear to them for its sake. After they had settled in Massachusetts they made some very strict laws, which stated: "Everyone must go to the Puritan church."

"No one may vote or take any part in making the laws except members of the church."

a. *Were these laws perfectly fair?*

b. *As a result of these laws, do you think everybody would be interested in the colony?*

34. Roger Williams was a settler who did not believe as the Puritans did. He said: "You do not own the land you live on. You got your claim to it from the King of England. But as he never owned the land he had no right to give it to you." He continued, "You have no right to tax people to support a church to which they do not belong. Nor have you the right to make people go to church."

Underscore the three words which describe Roger Williams' character: Just, fearless, sincere, cowardly, thoughtless, unfair, disloyal, pessimistic.

35. Roger Williams was forced finally to leave Salem. With six friends he selected a place for a settlement which they called Providence. This was the beginning of Rhode Island.

a. *What laws would you expect these settlers to make in regard to religion?*

b. *How do you think they secured the land on which they settled?*

36. The New England town meeting is said to be one of the great foundation stones of our democracy. All the laws were made in the town meeting. However, none but church members in the Pilgrim Church could vote. As the country continued to prosper many people of different beliefs came to the colony.

What law would you expect them to demand?

37. Conditions in the two earliest colonies, Virginia and New England, were very different. In Virginia the soil was rich, the climate was mild, the plantations were large, and the slaves well adapted to the cultivation of the soil. In New England the soil was rocky and the climate was cold. Yet the swift streams were useful for turning wheels for factories and mills. There were large forests. Both colonies had excellent harbors.

a. *What industries would you expect the New England colony to develop?*

b. *The Virginia Colony?*

38. In 1660 Charles I of England, who had been a very unjust and despotic ruler, was deprived of his throne and beheaded. Cromwell, one of the greatest of the Puritans, became the ruler of England. The royalists supported Charles I.

What class of people would you expect to emigrate to America during Cromwell's reign, Puritans or Royalists?

39. Henry Hudson was a bold navigator, who was employed by the Muscovy Company, a trading company of England. He started from Gravesend, England, with the intention of sailing straight across the North Pole.

Why didn't he do as he intended?

40. In 1607 Hudson sailed under the employ of a Dutch trading company. On this trip he again started north but later turned west and passed along the coast of Greenland and Newfoundland. He anchored for a time in the mouth of the Penobscot, sailed along by Cape Cod down to Chesapeake Bay, entered through the narrows and sailed up the Hudson beyond Albany.

Why do you suppose he searched so earnestly along the coast entering the bays and rivers and finally sail up the Hudson to Albany?

41. Germany recently tried to extend her borders by fighting. Holland did not kill men nor destroy homes but took her land from the sea. Where the most wonderful meadows are today there was once a wild waste of sea and sand. When

the land was reclaimed it was not only made fruitful but beautiful with trees and flowers.

Underscore three words that show the character of the people of Holland: Stingy, fruitful, considerate, ingenious, prudent, courteous, hopeful, extravagant, persevering.

42. In 1613 Hendrick Corstiaensen, a Dutchman, explored the Hudson and made a settlement of four houses on an island. He did not have a strong force and was in territory claimed by the English.

What do you think would be the attitude of the English toward the Dutch settlement?

43. The country which the Dutch claimed in America was rich in fur producing animals. The rivers were easily navigated. The Dutch were on friendly terms with the Indians.

What industry would you expect to be developed very extensively?

44. Manhattan Island, on which New York now stands, was purchased by the Dutch from the Indians for twenty-four dollars.

Give two reasons why this was a good bargain at the time.

45. Land for sixteen miles on one side of the Hudson, or eight miles on both sides, was given to any member of the Dutch West India Company who within four years would bring fifty settlers to the colony. Freedom of religion was granted to all. Four forts had been built in or near the region of New Netherland. Cattle, horses, hogs, and sheep were sent over from Holland.

What would be the influence on immigration of these activities?

46. In the patroon system, members of the East India Company were given eight miles on each side of the Hudson or sixteen miles on one side, if they should bring over fifty settlers. These members were called patroons. They built beautiful mansions on the lordly estates and the settlers cared for the estates. These settlers were to have a minister and a teacher but they were not allowed to vote, hold office or be tried by a jury, neither were they allowed to hunt, fish, manufacture or remove from the plantation for ten years.

a. Underscore three words that describe the government of New Amsterdam: Democratic, liberal, aristocratic, free, despotic, liberty-loving, tyrannical, just.

47. Since the Dutch people were a liberty-loving people, what kind of government would you expect them to demand?

48. The Dutch people demanded a share in making the laws of the colonies but the Dutch government would not yield any power to the people. The English in Plymouth, Massachusetts, Connecticut, and Rhode Island were ruling themselves and the Dutch longed for the freedom which the English had. When the English ships came into the harbor of New Amsterdam and demanded that the Dutch give up the colony to the English—

What would you expect the people of the New Amsterdam colony to favor?

49. Spanish, French, Dutch and English were among the discoverers and explorers of North America. These nations became rivals when the territories which each claimed overlapped. Settlements were made in disputed places as well as on disputed land.

What three things had each nation done to gain a claim to territory in North America?

50. What do you think happened when it was found that the settlements of these four rivals were made on disputed ground?

[Besides these questions, fifty additional questions were given.]

APPENDIX II

Appendix II consists of certain material on practice and correlation which has not been used in the body of the text. It is placed here for the benefit of students interested in improvement or relations of mental traits.

THORNDIKE INTELLIGENCE EXAMINATION FOR HIGH SCHOOL STUDENTS ON ENTERING COLLEGE CHILDREN OF SUPERIOR INTELLIGENCE

<i>Girls</i>															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
A.....	90	104	107	116	103	115	111	110	119	120	120	109	120	114	113
B.....	88	102	111	110	115	119	118	111	116	117	110	109	103	97	94
C.....	86	99	103	96	96	111	102	103	105	111	105	101	104	105	95
D.....	90	96	108	116	98	100	107	113	106	102	103	100	110	108	103
E.....	84	108	123	123	99	127	108	113	109	123	103	122	112	113	111
F.....	92	118	110	119	102	111	102	112	109	110	106	126	119	117	118
<i>Boys</i>															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
G.....	69	79	86	100	106	108	96	103	104	90	89	100	96	102	96
H.....	74	82	97	89	92	82	83	88	95	88	85	84	91	90	82
I.....	78	112	113	117	121	117	107	110	130	133	113	111	110	121	104
J.....	123	128	122	134	122	137	126	124	136	129	130	119	124	134	136
K.....	107	127	137	119	117	134	133	141	130	139	128	127	124	130	131
L.....	68	89	108	113	108	106	99	111	117	120	103	116	104	115	111
M.....	87	101	112	106	91	96	88	105	111	106	99	109	92	97	97
N.....	104	116	121	126	124	128	125	126	134	138	121	119	118	133	133
O.....	95	119	117	114	107	111	107	102	111	139	115	107	108	104	112
P.....	120	123	132	130	117	129	132	140	125	136	127	128	130	135	131
Q.....	81	92	95	89	94	93	95	93	102	109	91	94	92	101	95
R.....	75	95	100	110	103	112	100	110	108	113	98	115	106	117	111
S.....	115	120	129	121	108	125	129	122	123	129	114	124	126	129	118
Av.....	90	105.8	112.1	113	106.5	113.7	108.8	112.4	115.3	118.5	108.4	111.6	109.9	113.8	110

THORNDIKE INTELLIGENCE EXAMINATION FOR HIGH SCHOOL STUDENTS ON ENTERING COLLEGE CHILDREN OF AVERAGE ABILITY

<i>Girls</i>															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
A.....	64	67	76	72	82	80	84	79	75	80	97	74	89	94	92
B.....	61	68	69	70	64	77	74	80	82	90	86	85	80	86	81
C.....	54	70	72	81	85	80	95	89	79	107	86	85	92	99	90
D.....	52	101	68	88	84	82	84	84	83	87	82	95	99	82	84
E.....	42	68	68	94	77	78	63	76	75	81	76	72	73	68	77
F.....	56	76	74	84	84	84	79	94	96	93	97	93	91	92	95
G.....	56	92	71	87	98	101	86	96	97	98	95	96	107	102	100
H.....	54	69	77	81	82	68	81	89	95	95	91	94	91	97	83
I.....	48	65	77	85	78	87	74	87	99	84	85	86	87	82	77
J.....	59	86	84	80	90	92	87	90	89	90	81	97	100	101	102
K.....	47	66	61	93	82	82	75	74	85	65	62	75	79	66	70
L.....	40	70	69	67	68	67	67	69	66	64	63	62	78	67	68
M.....	48	74	74	82	68	67	88	88	80	84	79	91	86	91	75
<i>Boys</i>															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
N.....	39	57	54	68	83	82	72	63	72	62	76	67	54	73	79
O.....	52	69	65	90	83	76	74	66	76	77	79	78	76	79	67
P.....	67	65	66	68	93	67	79	76	83	86	80	100	96	96	104
Q.....	74	51	59	81	68	77	75	79	89	64	72	65	66	78	86
R.....	56	83	68	85	88	90	76	88	97	98	90	101	102	100	90
S.....	46	80	70	96	80	82	74	76	103	79	79	84	73	78	84
Av.....	53.4	72.5	69.5	81.7	80.9	79.7	76.9	81.2	84.8	83.4	81.9	84.2	85.2	85.8	84.4

**"RAW" CORRELATIONS BETWEEN INITIAL ABILITIES: COLLEGE STUDENTS
Groups A, B, and C together**

Addition and Substitution.....	.23	Substitution and Cancellation	
Addition and Cancellation 2&3,		2&3, 8&9.....	.455
8&9.....	.21	Substitution and Cancellation 4&7	.33
Addition and Cancellation 4&7....	.28	Cancellation and Cancellation....	.76

APPENDIX III

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